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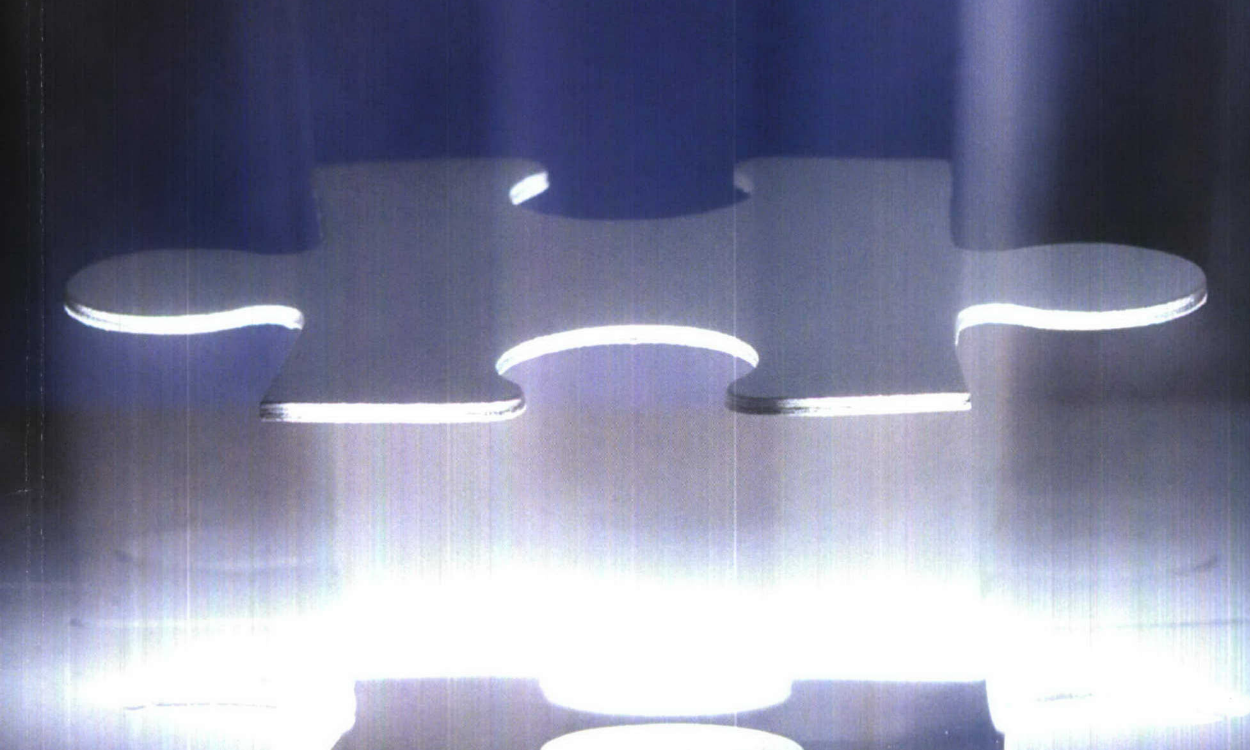
JL

AIR FORCE JOURNAL of LOGISTICS

Air Force Smart Operations for the 21st Century

also in this edition:

Establishing C-5 TNMCM Standards
Earned Value Management: Uses and Misuses
Inside Logistics
Candid Voices



Volume XXXII, Number 2
Summer 2008

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AIR FORCE JOURNAL of LOGISTICS

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Volume XXXII, Number 2 | **Summer 2008** | **AFRP 25-1**

The *Air Force Journal of Logistics* (*AFJL*), published quarterly, is the professional logistics publication of the United States Air Force. It provides an open forum for presenting research, innovative thinking, and ideas and issues of concern to the entire Air Force logistics community. It is a nondirective publication. The views and opinions expressed in the *Journal* are those of the author and do not necessarily represent the established policy of the Department of Defense, Department of the Air Force, the Air Force Logistics Management Agency, or the organization where the author works.

The *Journal* is a refereed journal. Manuscripts are subject to expert and peer review, internally and externally, to ensure technical competence, accuracy, reflection of existing policy, and proper regard for security.

The publication of the *Journal*, as determined by the Secretary of the Air Force, is necessary in the transaction of the public business as required by the law of the department. The Secretary of the Air Force approved the use of funds to print the Journal, 17 July 1986, in accordance with applicable directives.

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Unsolicited manuscripts are welcome from any source (civilian or military). They should be from 1,500 to 5,500 words. The preferred method of submission is via electronic mail (e-mail) to: **editor-AFJL@maxwell.af.mil**. Manuscripts can also be submitted in hard copy. They should be addressed to the *Air Force Journal of Logistics*, 501 Ward Street, Maxwell AFB, Gunter Annex AL 36114-3236. If hard copy is sent, a 3.5-inch disk, zip disk, or compact disk containing an electronic version of the manuscript should accompany it. Regardless of the method of submission, the basic manuscript should be in Microsoft Word or WordPerfect format, and all supporting tables, figures, graphs, or graphics must be provided in separate files (preferably created in Microsoft Office products; if Microsoft Excel is used to create any of the charts or figures, the original Excel file must be supplied). They should not be embedded in the manuscript. All submissions will be edited in accordance with the AFJL submission guidelines.

The Way Ahead

John Posner, Brigadier General, USAF
Ronald C. Ritter, PhD, USAF

Senior leaders across the Air Force have repeatedly stated that they cannot emphasize enough how important it will be to make AFSO thinking an integral part of every airman's daily routine.

On behalf of Secretary of the Air Force, Michael B. Donley, welcome to this special Air Force Smart Operations (AFSO) edition of the *Air Force Journal of Logistics*. We hope you will take the time to review some—if not all—of the articles outlining exciting and important AFSO initiatives happening across the Air Force.

AFSO didn't make airpower—it just makes it better.

If you are short on time, take a peek at our short article entitled, "Air Force Smart Operations – Here to Stay," which gives you a quick look at the genesis and future of AFSO. Hopefully that will entice you to read on and get your colleagues interested in learning more about Smart Operations.

As we look to the future, senior leaders across the Air Force have repeatedly stated that they cannot emphasize enough how important it will be to make AFSO thinking an integral part of every airman's daily routine. Therefore, on behalf of the Secretary of the Air Force, we will continue to facilitate AFSO efforts across the Service and we look forward to working with as many of you as we can.

As one Airman recently said, "AFSO didn't make airpower … it just makes airpower better." To maximize that effect, AFSO

Why AFSO21

- **Exciting.** Because these AFSO efforts involve the creativity and innovation of enthusiastic Airmen from every corner of the Service.
- **Important.** Because the work these Airmen are doing each and every day is helping to make a great Air Force even better. It's establishing a firm cultural foundation to keep the US Air Force the best in the world as we enter a future where the only certainty is the inevitability of increasingly complex threats to our national security and challenges to our vital interests around the globe.

must become part of the normal daily battle rhythm of the United States Air Force—we're depending on your help to make that a reality. So pitch in and feel free to let us know what exciting and important things you're doing for the Air Force today.

What Every Airman Should Know About AFSO

- Is in every airman's DNA
- Is necessary to the future success of the Air Force
- Provides a way to function effectively—even in a resource-constrained environment
- Exists for the sole purpose of helping Airmen strengthen mission capability
- Is critically dependent on *your* individual participation

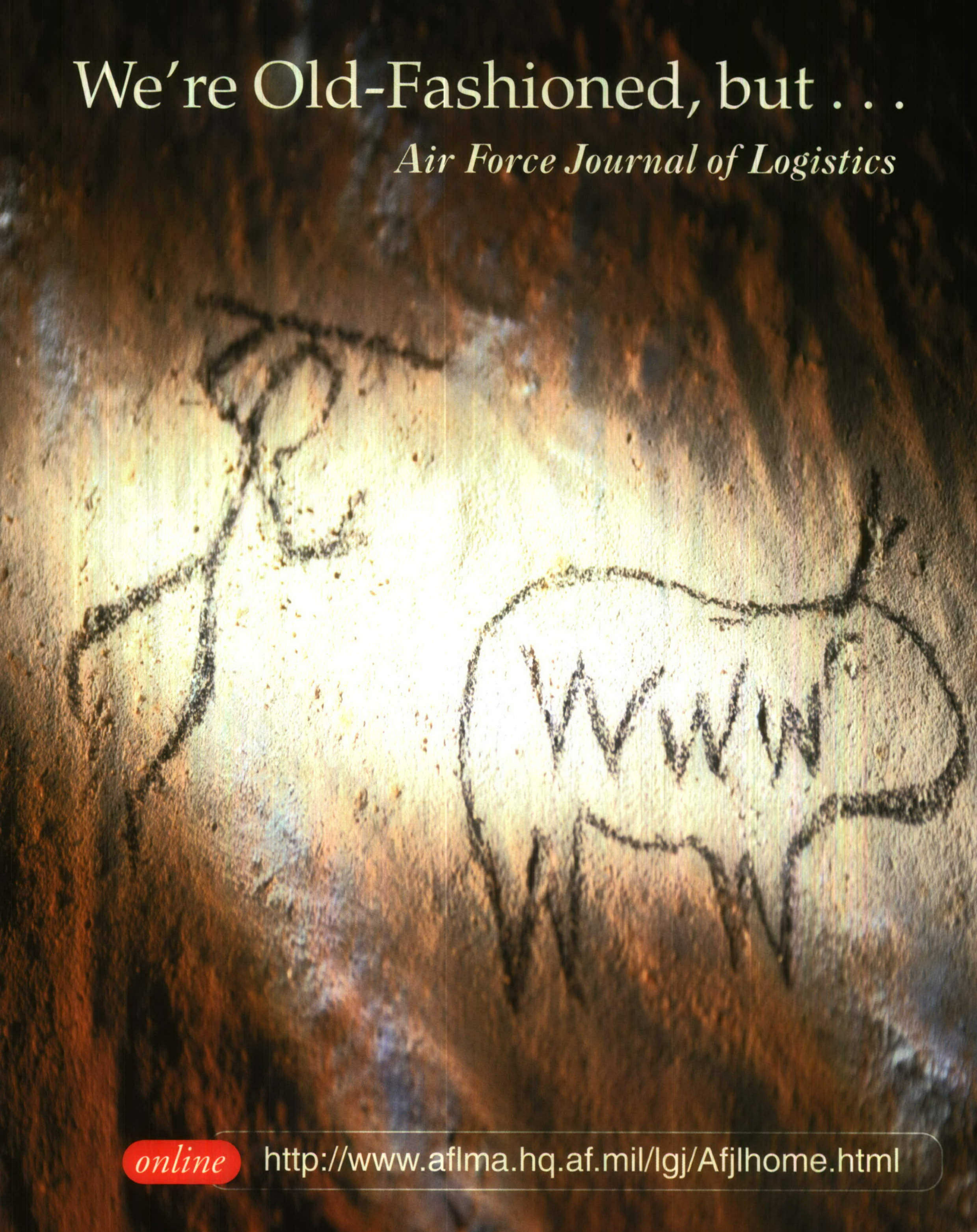
AFSO Senior Leadership

Brigadier General John Posner is the Director, Air Force Smart Operations, Office of the Secretary of the Air Force, Washington, DC. He is responsible for developing and coordinating the Air Force's AFSO21 transformational efforts. These activities include program design, management of the AFSO21 central team, development of core supporting initiatives in change management, training material, knowledge, and performance tracking. He also plays a direct role as advisor and continual process improvement mentor to senior Air Force leaders.

General Posner was commissioned in 1980 upon graduation from the US Air Force Academy and has served in a variety of training and operational assignments in the F-16, F-15, and T-37. He completed a tour on the Air Staff, working in numerous positions to include the Deputy Chief of Staff for Air and Space Operations Issues Team. He served on the Joint Staff as the Deputy Chief, Asia-Pacific Division (J5), and was later assigned to the Secretary of the Air Force staff as senior military assistant to the Under Secretary. General Posner commanded the Battle Staff Training School, Hurlburt Field, FL; the 363d Expeditionary Operations Group, Prince Sultan Air Base, Saudi Arabia; and the 27th Fighter Wing, Cannon AFB, NM. Prior to his current assignment, he served on the Joint Staff as Deputy Director for Operations - Operations Team One at the National Military Command Center. He is a command pilot with nearly 4,000 hours, including more than 200 combat hours.

Dr Ronald C. Ritter, a member of the Senior Executive Service, is the Special Assistant for Air Force Smart Operations to the Secretary of the Air Force, and Deputy Director of the Air Force Smart Operations Office, Washington, DC. He is responsible for developing and coordinating the Air Force's AFSO21 transformational efforts. These activities include program design, management of the AFSO21 Central Team, development of core supporting initiatives in change management, training material, knowledge, and performance tracking. He also plays a direct role as senior advisor and continual process improvement mentor to senior Air Force leaders.

Dr Ritter is a 1988 graduate of the University of Miami. He was selected as a Rhodes Scholar in 1988 and completed his doctor of philosophy degree from the University of Oxford. He spent more than 3 years in Botswana conducting field research with that country's government. He has spent the last 12 years in operations-related consulting at McKinsey and Company, a management consulting firm advising leading companies on issues of strategy, organization, technology, and operations. He was one of the early leaders in understanding and applying advanced Lean manufacturing methods to US operations, with a specific emphasis on large-scale transformation. He has direct, front-line experience in a wide range of environments, to include automotive assembly, heavy machining, aerospace production, aircraft maintenance repair and overhaul, petroleum, medical device, and pharmaceutical production. He left the firm as an Expert Principal, and had 7 years in a lead role of the North American Manufacturing Practice. He also served as Global Knowledge Committee Chair.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Facts and Glossary

The Editors, Air Force Journal of Logistics

AFSO21 signifies a shift in Air Force thinking. It is centered on processes (groups of tasks) rather than tasks alone, which allows the Air Force to gain insights into the value, or lack of value, in each task performed. It is built on successful principles from the corporate world, and has already yielded results in the Air Force.

Introduction

Air Force Smart Operations for the 21st Century (AFSO21) encapsulates the Air Force intent to develop and institutionalize a comprehensive, Service-wide, strategic-level, continuous process improvement approach. As stated in the *Air Force Strategic Plan*:

> We will capitalize on using knowledge from other organizations and disciplines to improve every business process within the Air Force. With AFSO21, we are challenging all Airmen to examine processes and eliminate steps in business processes that add little to no value.

In other words, the aim is to take high performing organizations to the next level, by reviewing how value is maximized and waste eliminated in all Air Force environments—operational, support, and otherwise—and fully integrate continuous process improvement across the total Air Force.

AFSO21 is an improvement model customized to the unique environment of the United States Air Force that leverages improvement methods from various sources such as Lean, Six Sigma, Theory of Constraints, and Business Process Reengineering. AFSO21 is a transformational initiative empowering all Airmen to eliminate waste from every end-to-end process. It is about delivery of warfighting capabilities today and tomorrow. It is about our warfighters successfully engaging and defeating our adversaries in 2015 and beyond. AFSO21 aligns the Air Force with a world-class continuous process improvement culture to create a standardized, disciplined approach. AFSO21 is applicable across organizational, functional, and capability boundaries with the ultimate objective of improving combat capability.

AFSO21 Vision

The vision for AFSO21 is to establish a continuous process improvement environment whereby all Airmen are actively eliminating waste and continuously improving processes. These improvements must be centered on the core missions the Air Force is responsible for conducting—specifically, to maintain the asymmetric advantages and capabilities the Air Force delivers in air, space, and cyberspace. Also inherent is the need to drive efficiencies and improvements across the board. Therefore, the Air Force must use the right tools and techniques to see and attack problems, leverage opportunities for improvement, and employ its greatest resource—innovative, dedicated Airmen. The vision directly supports the Air Force's mission statement. The desired effect is an increase in Air Force combat capability directly linked to the core Air Force mission.

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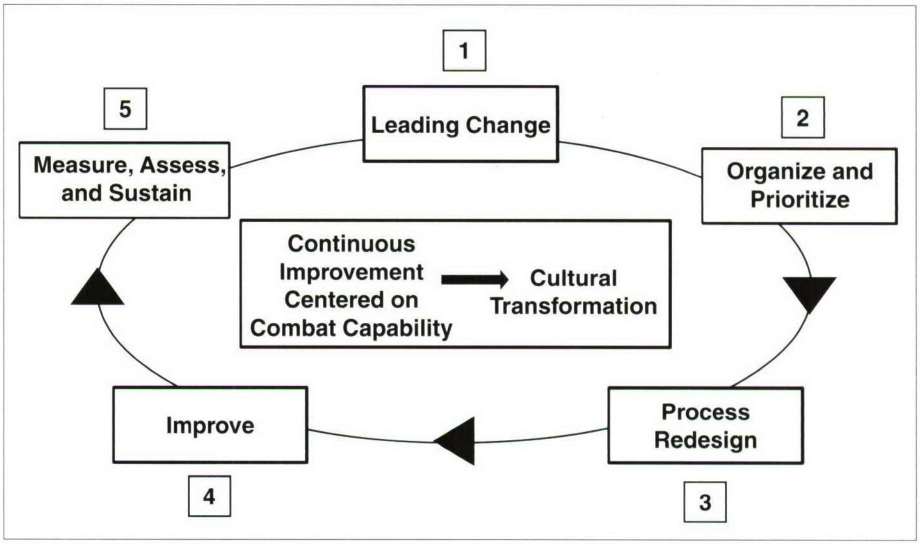
The sections that follow in this portion of the *Journal* provide the reader with some essential facts, a glossary of AFSO21 terms, and a listing of the acronyms used in the AFSO articles.

Key AFSO21 Principles

Continuous Improvement Cycle

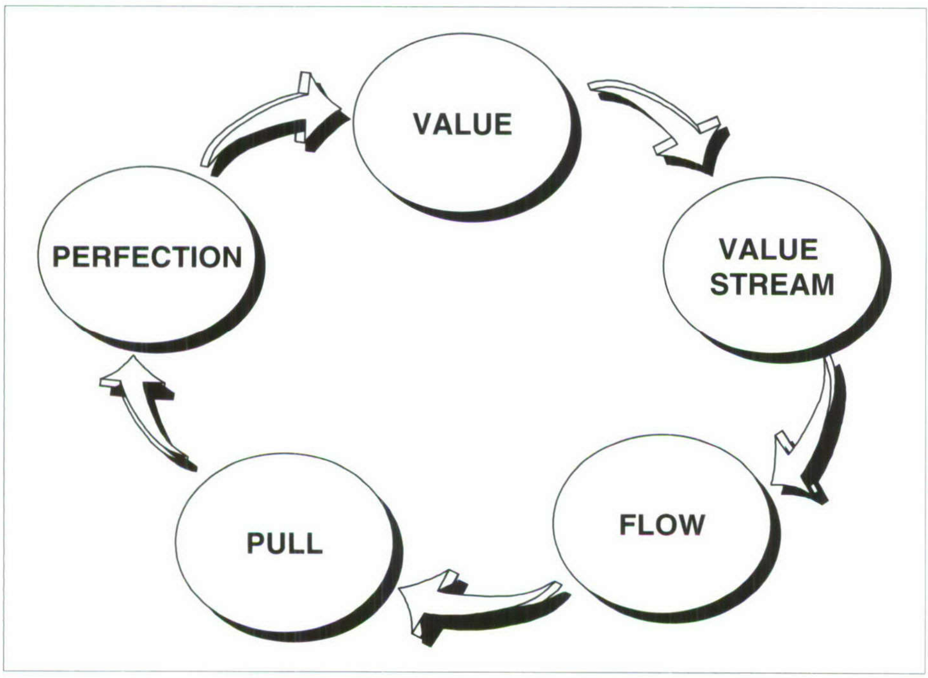
The AFSO21 continuous improvement cycle model consists of 5 steps. It can be applied to improvements in the shop area, within command processes, or to Air Force-wide processes. The steps can be applied to Lean projects focused on immediate improvements as well as to larger Business Process Reengineering efforts that involve much more time and many more



actions to implement and sustain improvements. The cycle can represent a quick improvement event accomplished over several weeks (typical of a Lean rapid improvement event), steps in projects that may take 2 to 4 months (typical of a Six Sigma project), or steps in a clean sheet reengineering effort that can take months to years to implement. The model reflects cycles of continuous improvement and revisiting how work is performed and how it can be further improved upon.

Five Principles of Lean

Lean is a systematic approach to identify waste, focus activities on eliminating it, and maximize (or make available) resources to satisfy other requirements. Lean is simply about removing waste. Achieving the Lean enterprise requires a departure from traditional thinking. The goal is to stop performing those activities and processes that do not add to a product or service's value. Five basic principles characterize a Lean enterprise. They are shown below.



Value: specify value from the customer's perspective.

Value Stream: characterize the value stream (set of activities) for each product and process while removing waste.

Lean is a systematic approach to identify waste, focus activities on eliminating it, and maximize (or make available) resources to satisfy other requirements. Lean is simply about removing waste.

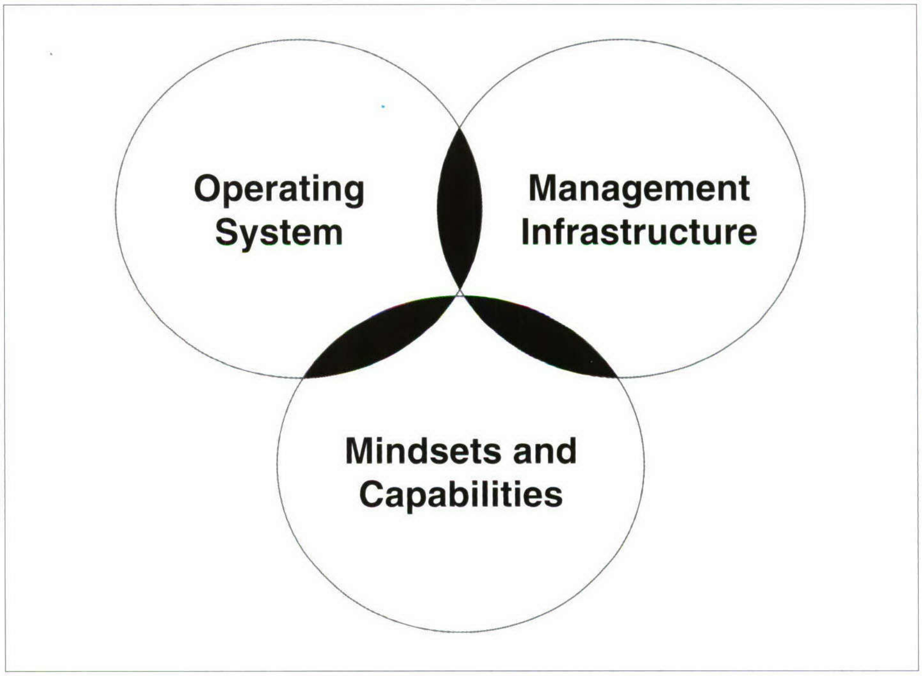
Flow: progressively achieving value creating steps with minimal queues and no stoppages or backflows of product, information, or services.

Pull: a system in which nothing is produced by a supplier until the customer signals a need.

Perfection: always compete against perfection, not just current competition.

Three Elements of Transformation

The three major components of any enterprise include its operating system, management infrastructure, and mindsets and capabilities. The greatest gain will come from improvements across the three components, vice limiting improvement activities to one. The three components are as follows:



Operating System: the physical tools and techniques to create value and minimize losses.

Management Infrastructure: the formal structures, processes, and systems through which the operating system is managed to deliver warfighting capability.

Mindsets and Capabilities: the way people think, feel, and conduct themselves in the workplace, both individually and collectively.

AFSO21 Tools

A variety of tools and methods are available to transform an organization or enterprise. They are listed below. A detailed discussion of each and how they can be used is found in the *AFSO21 Playbook.*

Situation Tools and Methods:

- Value Stream Mapping
- Constraint Analysis
- Metrics and Performance Measurement
- Go and See
- Risk Assessment and Capability Gap

Analysis Tools and Methods:

- Value and Waste Analysis
- Root Cause Problem Analysis
- Analysis of Alternatives
- Process Control
- Stakeholder Analysis
- Supplier, Inputs, Process, Outputs, Customer (SIPOC)
- Cost-Benefit Analysis
- Demand Analysis
- Enterprise Analysis and Action Planning
- Six Sigma and Statistical Analysis

Design Tools and Methods:

- Project Management
- Process Design
- Cell Design
- Visual Management
- Sort, Straighten, Shine, Standardize, Safety, and Sustain (6S)
- Line of Sight
- Material and Information Flow Design
- Systems Thinking and Management
- Quick Changeover
- Error Proofing
- Level Production
- Design of Experiments and Simulations
- Quality Function Deployment

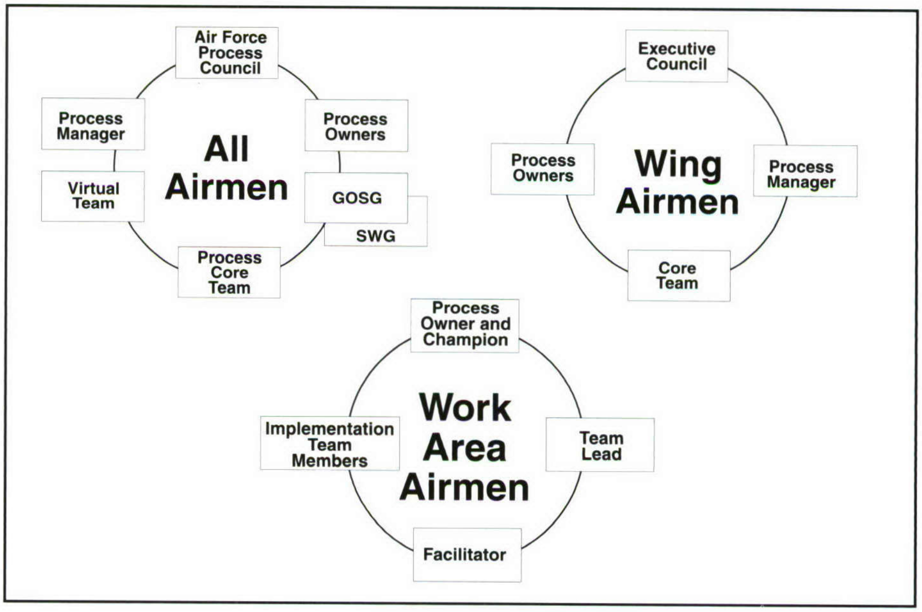
The *AFSO21 Playbook* is accessible at the *AFSO21 Knowledge Area* within *Air Force Knowledge Now* on the Air Force Portal at the following URL: https://rso.my.af.mil/afknprod/ASPs/CoP/FuncCoP.asp?Filter=OO-21. Select the CPI Resource Center icon to access the playbook and many other helpful AFSO21 materials.

Human Systems and Methods:

- Team Problem Solving
- Change Management
- Communications
- Rewards and Recognition
- Training and Education
- Understanding Roles
- Suggestion Systems
- Work Design and Ergonomics

AFSO21 Roles

Below is a macro-level view of the roles and responsibilities for key AFSO21 stakeholders and participants.



Essential AFSO21 Glossary

6S: Sort, Straighten, Shine, Standardize, Safety, and Sustain. A process improvement tool. An approach to cleaning up, organizing, and standardizing work:

- Sort (clear out rarely used items)
- Straighten (organize and label a place for everything)
- Shine (clean)
- Standardize (make standard the best known way to do something)
- Sustain (consciously continue to work the previous four items)
- Safety (ensure all hazards are removed)

Air Force Smart Operations for the 21st Century: The Air Force dedicated effort to develop and institutionalize a comprehensive, Service-wide, strategic-level, continuous process improvement approach. "We will capitalize on using knowledge from other organizations and disciplines to improve every business process within the Air Force. With AFSO21, we are challenging all Airmen to examine processes and eliminate steps in business processes that add little to no value" (*Air Force Strategic Plan*).

Air Force 8-Step Problem Solving Process: The 8-step problem solving process is an iterative approach which reflects continuous improvement and revisiting how work is performed and how it can be further improved. The 8-step problem solving process is based on the OODA Loop (Observe, Orient, Decide, Act) as originated in the 1950's by Colonel John R. Boyd, USAF. He defined how successful fighter pilots engaged in combat by repeating the decisionmaking process (OODA Loop) faster than their enemy, and he was able to help teach new pilots to do the same, improving their chances for success. Air Force leaders today increase the combat capability of their organizations by using the same infinitely repeating nature of decisionmaking emphasized by Colonel Boyd, using AFSO21 and continuous process improvement.

- **O**bserve: step 1 – clarify and validate the problem; step 2 – break down the problem and identify performance gaps
- **O**rient: step 3 – set improvement targets; step 4 – determine root causes
- **D**ecide: step 5 – develop countermeasures
- **A**ct: step 6 – see countermeasures through; step 7 – confirm results and process; step 8 – standardize successful processes

Balanced Scorecard: A strategic management system used to drive performance and accountability throughout the organization. The scorecard balances traditional performance measures with more forward-looking indicators in four key dimensions:

- Financial
- Integration and operational excellence
- Employees
- Customer

Constraint: Any resource whose capacity is less than the demand placed on it. Theory of Constraints attacks constraints and barriers (restrictions or other blocks to increases in output). If no demand is placed on the resource, but it is still the limiting step in a process it is called a *time trap*.

Continuous Process Improvement: A comprehensive philosophy of operations that is built around the concept that there are always ways in which a process can be improved to better meet the needs of the customer and that an organization should constantly strive to make those improvements.

Current State: Part of value stream analysis, this depicts the current state or as-is process—how it actually works in terms of operations, materiel, and information flow.

DMAIC: Define,Measure,Analyze,Improve, and Control. DMAIC is an ordered problem solving methodology applied widely in private and public sector organizations. The DMAIC phases direct a process improvement team logically from problem definition to implementing solutions that are linked to root causes, towards establishing best practices to help ensure the solutions stay in place. A Six Sigma tool.

ERP: Enterprise Resource Planning. A type of software package that attempts to consolidate all the information flowing through the enterprise from finance to human resources. ERP is used to standardize data, streamline the analysis process, and manage long-term planning with greater ease.

Facilitator: Consultant, advisor, or subject matter expert who leads or drives the pace and direction of a group participation event.

Five Whys: The problem solving technique of asking *why* five times to identify the root cause of a problem. Solutions to other than the root cause address symptoms and may provide temporary relief, but will not ensure that another symptom does not return in its place. The most effective countermeasures developed and implemented should address the root cause. This problem solving technique was made a standard practice by the US Air Force. This technique was made popular by Taiichi Ohno and Shigeo Shingo.

Future State: Part of value stream analysis. A vision of the optimum operating environment with new or improved processes in place.

Ideal State: Part of value stream analysis. A vision of the *future state* that depicts what the system should look like if there were no constraints. Based on the *King or Queen for a Day* mentality.

Just-in-Time: A strategy for inventory management in which raw materials and components are delivered from the vendor or supplier immediately before they are needed in the transformation.

Lean: A systematic approach to identify waste, focus activities on eliminating it, and maximize (or make available) resources to satisfy other requirements.

Non-Value Added: Any activity that takes time, materiel, or space, but does not add value to the product or service from the customer's perspective. For example, inspections or reviews normally are non-value added because they are checking to see whether the work was done right in the first place. A non-value added process step violates at least one of the following criteria:

- The customer is willing to pay for this activity.
- It must be done right the first time.
- The action must change the product or service in some manner.

Rapid Improvement Event: A short-term, high intensity effort to address a specific problem. The focus is typically a week, though the preparation normally begins several weeks before and followup continues after. Also called by other names, including Rapid Improvement Workshop, Kaizen Event, Kaizen Blitz, Accelerated Improvement Workshop.

SIPOC: Supplier, Inputs, Process, Outputs, and Customer. A SIPOC diagram is a tool used by a team to identify all relevant elements of a process improvement project before work begins. It helps define a complex project that may not be well scoped, and is typically employed at the Measure phase of the Six Sigma DMAIC methodology. It is similar and related to Process Mapping and *In/Out of Scope* tools, but provides additional detail. The tool name prompts the team to consider:

- The suppliers (the *S* in SIPOC) of your process
- The inputs (the *I*) to the process
- The process (the *P*) your team is improving
- The outputs (the *O*) of the process
- The customers (the *C*) that receive the process outputs

Six Sigma: A strategy that espouses increasing profits by eliminating variability, defects, and waste that undermine customer loyalty. Six Sigma can be understood or perceived at three levels:

- Metric—3.4 defects per million opportunities
- Methodology—a structured problem solving roadmap
- Philosophy—reduce variation in business and make customer-focused, data driven decisions

Subject Matter Expert: A recognized expert in a given area of knowledge (subject).

Supply Chain Management: Proactively directing the movement of goods from raw materials to the finished product delivered to customers. Supply chain management aims to reduce operating costs, lead times, and

inventory, and increase the speed of delivery, product availability, and customer satisfaction.

Theory of Constraints: A philosophy and a methodology for addressing logical thinking, scheduling and controlling resources, and measuring performance. The philosophy emphasizes that a systems constraint exists in any process and controls the output from the entire process.

Value Added: The parts of the process that add worth to the customer's product or service. To be considered value added, the action must meet all three of the following criteria:

- The customer is willing to pay for this activity.
- It must be done right the first time.
- The action must somehow change the product or service in some manner.

Value Stream Map: Identification of all the specific activities occurring along a value stream for a product or product family.

Waste: Anything that adds cost or time without adding value. Generally, waste includes injuries, defects, inventory, overproduction, waiting time, motion, transportation, and over processing waste. Waste is often placed into the following categories (D-O-W-N-T-I-M-E):

- Defects: having a direct impact to the bottom line, quality defects resulting in rework or scrap are a tremendous cost to organizations.
- Overproduction: to produce an item before it is actually required.
- Waiting: whenever goods are not moving or being processed, the waste of waiting occurs.
- Nonstandard Over Processing: often termed as *using a bazooka to swat flies*, many organizations use expensive high precision equipment where simpler tools would be sufficient.
- Transportation: moving product between processes is a cost that adds no value to the product.
- Intellect: human brainpower squandered in processes that do not require intelligent thought, such as expediting, chasing paper, and others. Any failure to fully utilize the time and talents of people.
- Motion: this waste is related to ergonomics and is seen in all instances of bending, stretching, walking, lifting, and reaching.
- Excess Inventory: stockpiles of both in-process and finished goods inventories are a direct result of overproduction and waiting.

Article Acronyms

6S – Sort, Straighten, Shine, Standardize, Safety, and Sustain
AFMx21 – Air Force Maintenance for the 21st Century
AFSO21 – Air Force Smart Operations for the 21st Century
ARM – Active Risk Management
BPR – Business Process Reengineering
CANS – Comprehensive Assessment of Nuclear Sustainment
CBT – Computer Based Training
CCPM – Critical Chain Project Management
CFETP – Career Field Education and Training Plan
CFT – Contract Field Team
COD – Council of Deputies
CPI – Continuous Process Improvement
CPI-MT – Continuous Process Improvement-Management Tool
D&SWS – Develop and Sustain Warfighting System
DMAIC – Define, Measure, Analyze, Improve, Control
DoD – Department of Defense
ERRC – Engine Regional Repair Center
GLMFI – Global Local Manufacturing Factory Initiative
GLSC – Global Logistics Support Center
GOSG – General Officer Steering Group
GWOT - Global War on Terror
IT – Information Technology
JACOT – Joint Air Cargo Operations Team
K-S – Kolmogorov-Smirnov
MAF – Mobility Air Forces
MTD – Maintenance Training Device
OODA – Observe, Orient, Decide, Act
ORR – Operational Risk Reduction
PDM – Programmed Depot Maintenance
PE – Periodic Inspection
QEC – Quick Engine Change
RIE – Rapid Improvement Event
RNT – Repair Network Transformation
SA&D – Strategic Alignment and Deployment
SIPOC – Supplier, Inputs, Process, Outputs, Customer
SME – Subject Matter Experts
SWOT – Strengths, Weaknesses, Opportunities, and Threats
TOC – Theory of Constraints
TQM – Total Quality Management
VSM – Value Stream Mapping
UE – Undesirable Effects

Featured Efforts and Studies

The Editors, Air Force Journal of Logistics

While the vast majority of good ideas come from the front line, Airmen at all levels have a role to play. Mid-level officers and noncommissioned officers have the experience and operational responsibility to identify opportunity areas and guide Smart Operations work.

Air Force Smart Operations for the 21st Century (AFSO21) builds on initial successes and work to broaden process improvement efforts in Air Force operational, maintenance, logistics, and support environments. Fundamentally, AFSO21 is a method to see and resolve problems as well as a mindset of continuous improvement grounded in mission results. It emphasizes the use of the Air Force's greatest resource in doing so—dedicated Airmen, guided by world-class leadership and unique core values. It is a transformational initiative that eliminates waste from end-to-end processes. It also focuses on working smarter to deliver warfighting capabilities.

In this section of the *Journal* AFSO21 in action is highlighted. The selection of articles includes everything from AFSO21 basics to using the right AFSO21 tools and techniques to solve time sensitive, demanding problems. Brigadier General Posner and Dr Ritter introduce the section and this is followed with three articles that illustrate AFSO21 basics, tools, and techniques. The section concludes with a series of articles that illustrate AFSO efforts and initiatives—good news to say the least.

AFSO21 Purpose

AFSO exists for the sole purpose of helping Airmen continue to strengthen mission capability. AFSO is all about doing your job faster, better, more safely, and smarter. It is important to understand that AFSO doesn't make decisions to cut or constrain resources. Quite the contrary, AFSO helps Airmen deal effectively in an environment where those limitations already exist.

Air Force Smart Operations **in action**

Air Force Smart Operations for the 21st Century

Here to Stay!

While the specific nature of the challenges we will face remains uncertain and dynamic, one of the inherent strengths of Air Force Smart Operations (AFSO) is its flexibility to effectively address any unique set of circumstances. In this regard, it is easy to see that AFSO exists for the sole purpose of helping Airmen continue to strengthen mission capability. AFSO is all about doing your job faster, better, more safely, and smarter. It is important to understand that AFSO doesn't make decisions to cut or constrain resources. Quite the contrary, AFSO helps Airmen deal effectively in an environment where those limitations already exist.

Brigadier General John Posner, USAF
Ronald C. Ritter, PhD, USAF

The Air Force has a long and proven history of using innovation to solve problems, reduce risk, and create new opportunities—but, perhaps most importantly, for using innovation to exponentially increase combat airpower capability. As our former Chief of Staff, General T. Michael Moseley, frequently remarked, "... it is in every airman's DNA." Over the 60-plus-year history of the United States Air Force, and for many more years before that during the genesis of airpower in the Army Air Corps, the immutable and unique characteristics of airpower—precision, speed, lethality (just to name a few)—have all witnessed extraordinary improvement.

Throughout this evolution of airpower, one enduring principle remains true—it is the ideas and creativity of front-line Airmen that continue to fuel this continuous strengthening of mission capability. Engaging the imagination and initiative of our people is not only the right thing to do, it is, without question, necessary to the future success of the Air Force. Supervisors and leaders across the Service, therefore, have an obligation—and daily responsibility—to make the absolute best use of airmen's time and strive

to constantly improve the operational performance of the Air Force.

Of particular note, many of the innovation initiatives adopted by the Air Force have their roots in the business sector where their intrinsic value has been tested and proven over time. This tried-and-true formula for success has now brought us Smart Operations.

The earliest activities related to AFSO began in the air logistics centers. AFSO has now spread to virtually every aspect of the Air Force daily battle rhythm. After years of dedicated and focused efforts—from the most senior Air Force leaders to the most junior Airman—AFSO is now on a very steep vector and climbing. Secretary of Defense Robert M. Gates recently highlighted the Air Force for transforming: "... the institutional culture that empowers Airmen ... to challenge the status quo and take responsibility for building a stronger Air Force."

Current and future challenges—perhaps best described generically as additional mission taskings, whether that be continuing Global War on Terror operations, aging fleets, increased security requirements, and others—are placing ever greater demands on airmen's time with little to no relief in sight. In addition, resource availability forecasts continue to show significant limitations for military budgets in the foreseeable future—leading the Air Force to find a way to ensure mission execution within existing or even reduced funding. Against that challenging backdrop, the need for finding efficiencies becomes even more critical.

There is, however, some very good news. AFSO provides a proven way to function effectively—even in a severely resource-constrained operating environment. This is not just some unsubstantiated claim. We have seen this time and time again in the business sector where organizations that successfully implement the discipline of Lean thinking have not just survived, they have completely dominated their competition. This should sound familiar to Airmen because the Air Force has never been interested in just competing. It has a long history of a single-minded focus on completely dominating any would-be adversary.

In that regard, all Airmen should have a deep and abiding interest in what Lean can do for them—and senior leaders are all in. In fact, the commander of Air Combat Command (ACC), General John D.W. Corley, recognized the great potential inherent in AFSO and initiated a *war on waste*. The focus of his campaign is to enhance mission performance throughout ACC by looking at how we are spending our time, studying our processes for mission value, and using the Lean tools available within AFSO21.

While the vast majority of good ideas come from the front line, Airmen at all levels have a role to play. Mid-level officers and noncommissioned officers have the experience and operational responsibility to identify opportunity areas and guide AFSO work. Senior leaders set the course and more than ever, personally lead large, high-value initiatives like aircraft fuel, additional duties, and information technology overhaul.

Finally, it is important to note that Congress has also recognized the power of Lean and has directed the Secretary of Defense, in the 2008 National Defense Authorization Act, to implement business transformation efficiency programs across all of the military Services. To date the result has been a Congressional requirement to appoint a chief management officer to direct the Department's efforts and a standing directive by the Deputy Secretary of Defense on continuous process improvement. For the Air Force, AFSO21 has emerged as a core component of its strategy to meet these Department of Defense mandates.

While the specific nature of the challenges we will face remains uncertain and dynamic, one of the inherent strengths of AFSO is its flexibility to effectively address any unique set of circumstances. In this regard, it is easy to see that AFSO exists for the sole purpose of helping Airmen continue to strengthen mission capability. AFSO is all about doing your job faster, better, more safely, and smarter. It is important to understand that AFSO doesn't make decisions to cut or constrain resources. Quite the contrary, AFSO helps Airmen deal effectively in an environment where those limitations already exist.

On behalf of the Secretary of the Air Force, we will continue to facilitate AFSO efforts across the Service. We look forward to working with as many Airmen as we can as we strive to make all Airmen more conscious of their *AFSO DNA* by making an AFSO mindset an integral part of every airman's daily routine.

Together we can give a great Air Force an even better future—a future in which the Air Force is a much more lethal force and a much more effective partner on the Joint warfighting team; a future in which the Air Force will be able to provide a wider array of sovereign options to our national leadership, where they can

choose to employ an even more capable Air Force to meet the increasingly complex national security challenges and threats our country will inevitably face.

While this overall effort is important, your individual participation is that much more critical. So, pitch in to the AFSO fight. We're absolutely confident it won't take long before you too see the true value, and appreciate the professionally rewarding aspects of how AFSO can help you do your part to make this great Air Force that much better.

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The Basics

Air Force Smart Operations for the 21st Century

Air Force Smart Operations for the 21st Century (AFSO21) was introduced as an initiative, in part, as a response to the Air Force's need to modernize and recapitalize our aging aircraft and equipment fleet. Antiquated and *stove-piped* processes contributed to wide spread inefficiency throughout all areas of the Air Force, ranging from administration to production processes. It includes the commercial practices of four proven process improvement methodologies, all of which share the traits of continuous process improvement (CPI). These methodologies are Lean, Six Sigma, Theory of Constraints, and Business Process Reengineering. Key principles contained in these methodologies include improving flow within a process, focusing on factors that degrade quality in products, identifying and overcoming constraints within a process, and complete redesign of a process.

Major Anthony F. Antoline, PhD, USAF
Steven Green, The Greentree Group

How can we be more effective at our jobs with efficiency built into the processes we have to execute every day? This is not a rhetorical question—leadership expects an answer. In order to meet the challenges we face daily, we must work smarter. AFSO21 is the instrument to get this accomplished. This article describes the basics of ASFO 21, provides some history, describes its principles, and discusses some of the AFSO tools available.

Air Force Smart Operations in action

What is the goal of implementing AFSO21 across the Air Force? The vision statement lays this out clearly.

> The vision for AFSO21 is to establish a continuous process improvement (CPI) environment whereby all Airmen are actively eliminating waste and continuously improving processes. These improvements must be centered around the core missions we, as Airmen, are responsible for conducting—specifically to maintain the asymmetric advantages and capabilities the Air Force delivers in air, space, and cyberspace. We need to ensure we are also driving efficiencies and improvements across the board. Therefore, we must use the right tools and techniques to see and attack problems and leverage opportunities for improvement; and employ our greatest resource—innovative, dedicated Airmen.[1]

AFSO21 is not centered around one process, base, or major command. The Air Force is implementing AFSO throughout its entire enterprise. AFSO focuses on the components of the enterprise, the operating systems or tools and techniques we use, and the management infrastructure—including the structure, processes, and systems—that are required to execute the Air Force mission. Further, AFSO is very much about changing the mindset and capabilities of the people executing the Air Force mission. Simply put, it provides the tools and techniques to improve areas that are overburdened or inflexible, improve standardization, and eliminate waste.

Why AFSO21

AFSO21 was introduced as an initiative, in part, as a response to the Air Force's need to modernize and recapitalize its aging aircraft and equipment fleet. Antiquated and stove-piped processes contributed to wide spread inefficiency throughout all areas of the Air Force, ranging from administration to production processes.

AFSO21 includes the commercial practices of four proven process improvement methodologies, all of which share the traits of continuous process improvement. These methodologies are Lean, Six Sigma, Theory of Constraints (TOC), and Business Process Reengineering (BPR). Key principles contained in these methodologies include improving flow within a process, focusing on factors that degrade quality in products, identifying and overcoming constraints within a process, and complete redesign of a process.

The five desired effects of AFSO21 are as follows:[2]

- Increase productivity of the Air Force's most valuable asset—Airmen
- Significantly increase critical asset availability
- Improve response time and decisionmaking agility
- Sustain safe and reliable operations
- Improve energy efficiency

Lean

AFSO21 is largely based on the principles of Lean. Lean focuses on the identification and elimination of waste within a process and sets the stage for other CPI approaches, making them more effective. Five basic principles characterize a Lean enterprise—specifying value, value stream identification, flow, pull, and perfection.

Value

Defining value is the critical first step in the Lean process. From a Lean perspective, value is defined by the ultimate customer and is only meaningful when expressed in terms of a specific product that meets the customer's needs at a specific price and at a specific time.[3]

Value Stream Identification

The next step in the process is identifying the value stream which includes all actions required to deliver a product to the customer, to include waste. The identification of the value stream is best accomplished using value stream mapping (VSM). VSM involves developing a visual depiction of the process, identifying each activity from beginning to end.

Flow

After the value stream is specified, the next step is to determine if the process flows throughout the value stream with little to no interruption. The greatest hindrances to flow are traditional batch processing and departmentalization which occurs when work is performed in groups and then passed on to the next step in the process or to another department for further processing. This contributes to longer lead times because of the amount of wait time between process steps.

Pull

Pull enables the customer to extract the product from the value stream based on demand (as needed). Simply put, nothing is produced by a supplier until the customer signals a need. The benefits of the pull are providing the right amount of product or service, at the right time, when needed by the customer. This significantly decreases, or sometimes eliminates, the requirement for large stockpiles of inventory that can be a source of waste within the value stream.

Perfection

The fifth Lean principle is the endless pursuit of perfection—all activities along the value stream become value added. Continually revisiting the process will identify additional waste that can be eliminated, thus moving the process ever closer to the state of perfection.

There are eight specific forms of waste defined by Lean. Day-to-day activities are full of wasteful steps, and identification and elimination of waste is critical in improving a process. The following is a list and brief description of each form of waste:[4]

- **Defects.** Defects cause rework and increase costs. Valuable resources are consumed reworking and correcting errors associated with defects. Examples are incorrect documentation, missing information, rework, and scrap.
- **Overproduction.** This occurs when more information or product is generated than needed, leading to excess inventory. Examples are batch processing and making too many copies of a document or presentation.
- **Wait-time.** This includes all idle time within a process. Examples range from waiting for a fax to waiting for delivery of a required part to complete a work order.
- **Nonstandard Over-Processing.** This form of waste has no value from a customer perspective. Nonstandard work practices and over inspection of items or parts are examples of this waste.
- **Transportation.** This is the unnecessary movement of information or materials. Examples include physical hand-off of information and moving materials or products in and out of storage.
- **Intellect.** This form of waste arises from not capitalizing on expertise and knowledge of individuals within an organization.
- **Motion.** Any activity requiring movement by a person or machine that does not add value to a process is wasted motion. Examples are searching for lost parts or tools and walking too far to use a copier.
- **Excess Inventory.** Excess inventory results from keeping too much information or material than is needed to fulfill a customer order. Forms of this waste include producing documentation ahead of customer orders and unnecessary parts or product inventory.

Adhering to the Lean principles—specifying value, value stream identification, making the process flow, pulling value from the customer, and the endless pursuit of perfection—provides a clear path to process improvement. Equally important is the identification and elimination of waste within the process to create overall value in the eyes of the customer. As Lean seeks to identify and eliminate waste, Six Sigma seeks to reduce variation within a process or product while improving quality and reducing cost.

Six Sigma

Six Sigma is another methodology under the AFSO21 umbrella. The use of Six Sigma as a process improvement method means using a disciplined, data-driven approach to measuring the defects produced by a business process and then systematically determining how to remove them.[5] The ultimate goal is to reduce variation in a product or process to no more than 3.4 defective parts per million opportunities. Define, Measure, Analyze, Improve, and Control (DMAIC) is the structured problem-solving methodology used for the five phases of Six Sigma improvement.[6]

DMAIC

- Define the purpose and scope of the project. It is also important in this step to capture the voice of the customer, which in short, is capturing the customer's requirements.
- Measure the current state of the process and collect reliable data on process speed, quality, and costs that will be used to expose underlying causes of problems.[7]
- Analyze the process to identify root causes of problems affecting the product or process and support these discoveries with data.
- Improve the process by implementing solutions to root causes and create measurement standards to evaluate results.
- Control the process by documenting and standardizing improvements to prevent workers from going back to the old way of doing business. It is also important to develop metrics to be used for regular process auditing.

The DMAIC framework should be utilized when an existing process or product is not meeting customer requirements. As Lean and Six Sigma address improvement to individual processes, there is another improvement methodology that takes more of a systems view and focuses on eliminating constraints within the system—Theory of Constraints.

Theory of Constraints

TOC is a management philosophy introduced by Eliyahu Goldratt in his 1984 book *The Goal*. It is based on the principle that complex systems exhibit inherent simplicity. Even a very complex system made up of thousands of people and pieces of equipment can have at any given time only a very small number of variables—perhaps only one (know as a constraint)—that actually limits the ability to generate more of the system's goal.[8] The purpose of TOC is to correctly identify and eliminate the constraint or constraints.

The objective of TOC is to maximize the throughput of a process while minimizing operating expenses in the form of labor resources and costs.[9] TOC focuses on five key steps in implementing continuous improvement. Although not formally a step in this process, it is vitally important to correctly articulate the goal to the organization before embarking on the process of change.

Five Steps of TOC Application[10]

- **Identify and Prioritize the System's Constraints.** Here a process is analyzed so that a task or activity that limits the productivity of an entire system can be identified. Be mindful that a constraint can be a physical or policy constraint. A physical constraint will require a strengthening of the weak link in the process chain. Policy constraints require replacement of the policy.[11]
- **Exploit the Constraint.** In this step, decisions must be made on how to modify or redesign the task or activity so that work can be performed more effectively and efficiently.
- **Subordinate the Constraint to All Other Processes.** All efforts are directed at improving the performance of the constraining task or activity and any other task or activity that directly affects the constraining task or activity.
- **Elevate the Constraint.** This may require a permanent increase in capacity that will increase (elevate) the overall output of the constraining task or activity. It can include purchasing more equipment or machinery, implementing a new information technology program, or hiring additional personnel.
- **Return.** If the constraint is removed, return to step 1 and begin the process again.

The assumption is that once a constraint is broken, another will surface within the process. Following the five steps of TOC will enable continuous improvement of both the overall system and its processes. The three previously described methodologies focus on incremental improvement within a process. Business Process Reengineering, on the other hand, is a comprehensive process requiring a change in the fundamental way business processes are performed.[12]

Business Process Reengineering

To maintain competitiveness in today's global marketplace many companies are using BPR. In a world of unprecedented customer power, past performance is no longer acceptable, and conventional remedies do not address non-value added activities within business processes.[13] Removing waste and minimizing non-value added work from a process is the major focus of BPR.

BPR is not about incremental improvement. It focuses on inventing a totally new business process from a *clean slate* perspective. It doesn't mean tinkering with what already exists or making incremental changes that leave basic structures intact.[14] It is a complete rethinking of how the process should be performed with a major focus on creating value from a customer's perspective. BPR also focuses on reducing costs and accelerating the flow of information throughout a process. Technology acts as an enabler for BPR by enhancing the flow of information from both within an organization and across organizations.

The BPR methodology addresses envisioning a new process, change management, process diagnosis, process redesign, implementation, and monitoring of the new process.

BPR Methodology[15]

- **Envision New Process:** secure management support, identify reengineering opportunities, identify enabling technologies, and align with corporate strategy
- **Initiating Change:** set up reengineering team and outline performance goals
- **Process Diagnosis:** describe existing process (who, what, why, and how) and uncover pathologies in existing process
- **Process Redesign:** develop alternative process scenarios, develop new process design (future state process), design human resource architecture, select information technology (IT) platform, develop overall blueprint, and gather feedback
- **Implementation:** develop and install IT solution, implement process changes

- **Process Monitoring:** performance measurement (including time, quality, cost, and IT performance) and link to continuous improvement

Lean, Six-Sigma, TOC, and BPR are all important and proven CPI tools. A onetime effort will produce improvement, but utilizing CPI concepts will prevent process stagnation, continuously improve processes, and instill a culture of continuous improvement within an organization. Ingraining the CPI mindset into the Air Force culture is a necessary and positive step forward and using the tools available will help create this mindset. CPI tools and methodologies are discussed in the *AFSO21 Playbook,* which is available via the AFSO21 Community of Practice.

Facilitator Tools—The Rapid Improvement Event

The AFSO office has detailed the tools and methodologies available to a facilitator in the *ASFO 21 Playbook.* If you have been involved in an event, you have witnessed several of these tools put to use. If you have not, this section will familiarize you with a typical rapid improve event (RIE) utilizing the Value Stream Mapping (VSM) methodology and other tools commonly utilized throughout an event.

If the problem being evaluated is manageable with a small number of people, an RIE may be tailored and a small project (just-do-its) may be sufficient to make the improvements needed. Often the problem is larger and several organizations or offices are involved in an RIE. Incorporating various problem-solving tools may be the best route to getting everyone on the same page.

Keep in mind that an RIE does not just happen. There is coordination that must be done beforehand. The guiding document for an RIE, the charter, needs to be developed (4 weeks out) and approved (3 weeks out).[16] The charter sets the goals and scope of the event for participants and the sponsor. It also will help ensure that the event fulfills the sponsor's expected outcome (solutions developed and manpower and resources not wasted).

The first day of an event is a busy one. The foundational work for a successful meeting is set during this critical time. Once the introductions are made, ground rules have been set, and jobs given to the participants (timekeeper, scribe, and others), the facilitator will outline the expectations for the group. An open environment that keeps participants engaged and feeling they are contributing to the event is essential. The charter needs to be briefed to ensure everyone understands what the RIE is about and what the team is expected to accomplish. Often the sponsor will address the group and express support for the event and give his or her views and guidance. Once this occurs, the event is ready to roll and will be turned over to the event team lead and the facilitator.

The event team lead does much of the preparation for the meeting and should be in contact with leadership to ensure support. This also allows the lead to brief leadership on issues that might affect the success of the event.[17] The facilitator will run the event and ensure the activities are properly scoped, planned, and carried out.[18] Many good ideas and questions will be generated during the course of the event that may not fit in the scope of the RIE or that may need to be answered later. The facilitator will establish a running list of these items in what is termed the *parking lot.* These items will need to be revisited before the group adjourns and may be used as part of the outbrief or implementation plan.

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Part of the facilitator's responsibility during the event is to conduct an AFSO awareness brief that puts the group on an even playing field. When an event is hosted, the participants' AFSO experience will vary—in some cases, it may be their first exposure. The awareness briefing will provide all the participants a glimpse of

what AFSO21 is, what is going to occur, and what they will be responsible for throughout the event.

The facilitator will then take note of the participants' experience and start to validate the data sources for the event. If possible, real data from observing the process in question should be used rather than historical data or best guesses.[19] Once the review has been accomplished, the facilitator will review the steps to create a VSM, which will define the current state of the process used to produce the end item or service under consideration.

Before getting too far into what is currently happening with the process, defining the impact of the process and those involved is useful. The facilitator will typically use a tool that gives the group a good reference point from which to start, defines the process at a high level, and helps scope the project. A SIPOC (Supplier, Inputs, Process, Outputs, Customer) is the tool used to do this. It pinpoints the *supplier* to the process, the *inputs* the supplier has to the *process*, names the process that is under scrutiny, defines the *outputs* of that process and, identifies the *customer* who receives the outputs of the process.[20] Narrowing the scope and discussing how each element delivers value to the customer is complemented by actually taking the group to see the process in question. At the very least, the team lead should do this to ensure he or she is able to lead the group and keep the event on track. It may help to draw the process—a spaghetti diagram can be utilized— to define the flow of the product through the process.

Next, each step of the process is mapped out. This portion of the VSM takes a significant amount of effort. The VSM is core to the analysis the group will accomplish, so getting it right is imperative. During this effort the group is not only labeling each step, it is assigning touch time, cycle time, number of people in the step, and cost of the step.[21] Touch time is the time spent in which the item is actively being worked. Cycle time is the time from receipt to release. If touch time and cycle time appear to be the same, the facilitator would want to verify that is, in fact, the case. (Often items sit and wait before they are actually processed; sometimes technology can expedite this and bring those times closer together.)

Once the current state is fully developed, the group will start to identify the problem by labeling each step as value added, no value added, or no value added but required. Consider the value added to the product or service from the customer's point of view.[22] Frequently a member or members of the group are responsible for part of the process and that portion will be very important to them. Two questions need to be asked. Would the customer care about that step? Does it add form, fit, or function to the product or service? Participants may have a difficult time divorcing themselves from the process and focusing on the value to the customer.

Once the as-is VSM is complete, the gloves come off and the group's next exercise is to define the perfect state for the process. The team should define the process as it should be with no budget, technology, or regulatory constraints—the goal being to completely eliminate waste. This will help to illustrate the amount of waste that is in the as-is process. The group will assign *value* or *no value* to these steps as was done before.

Once the group has an idea of what the future state can be, it will evaluate the current-state map for undesirable effects (UE). UEs are symptoms of the problems in the process. These problems need to be analyzed for root causes. A facilitator can utilize several techniques to discern the *real* cause of a problem. The Five Whys is one method. You may have done this as a young child to irritate your parents, but it can lead to a solution, as long as the questions are focused on the last response. Simply ask, "Why did (insert the problem here) happen?" Repeat this five times, more or less, and the root cause is likely to reveal itself.[23]

Solutions directed at issues other than the root cause may lead to a small improvement and may only address the symptoms, not the actual core issues. Some facilitators may use a fishbone diagram to ensure the root cause is identified. This method seeks to organize like issues, much as an affinity diagram does. The diagram will resemble a fish skeleton, with six ribs branching off a central spine. A problem statement serves as the head, with the six ribs representing the six broad categories of causal factors: manpower, machine, method, material, measurement, and environment.[24] These factors can be traced back to the problem. You might find that you can eliminate some causes if they cannot be traced back to the head. Other tools, such as brainstorming or the Observe, Orient, Decide, and Act Loop method, may be used to seek solutions to the problems. Once the solutions are formed, the group will design the future state of the process.

The future state should be designed for a 3 to 6 month period into the future. This will allow time to implement some of the solutions the group has developed. The changes that must occur to amend the current state to the future state are noted, and each step is labeled in regard to value as before. What will become apparent

is that there are many opportunities to eliminate waste, idle time, and inventory, as well as improve information flow and the overall process.[25] You may also find that many requirements are levied on your processes that are driven by Occupational Safety and Health Administration guidelines, Air Force instructions, or some other mandate. If the solutions developed can be done safely and legally, challenge the standard.

Once the group has the solutions to the problems listed, it needs to prioritize them and determine how much work will be required for implementation. Some solutions will be classified as *just-do-its* which are easily accomplished. However, just-do-its may require another RIE to get to the root of the real problem. Solutions that will require significant time will be termed projects. A project may take several months and require research to accomplish. To prioritize solutions, the facilitator will normally use a tool called a pick chart. This is simply four quadrants with *difficulty* running along the x-axis and *level of impact* running down the y-axis. The solutions are then placed on the quadrant where the group thinks they should be listed. This is a simple way to determine which solution should be tackled first and where to get the greatest results for the least level of effort. With this accomplished, the group can develop an implementation plan and assign points of contact, as well as start and stop dates to ensure the tasks get accomplished. The implementation plan is the heart of the RIE. It is the plan that enables the solutions to come to fruition.

The sponsor also needs to be briefed on the group's findings and the implementation plan. When stepping through the outbrief, group members get to play a part and explain some of the events that have taken place during the week. One comparison that needs to be highlighted during the outbrief is the difference between the current as-is process and the future to-be process—savings of time, resources, and money by the elimination of waste. All is not done at this point, however. The group spent its time coming up with a plan, now comes the real work to execute it. Ensuring the ideas are implemented and periodically reviewed is the only way to see returns from the team's hard work.

Conclusion

The Air Force is proving itself as a first-class example of how to use peoples' initiative and ideas to make the enterprise better. Keeping the basic AFSO principles in mind while doing our day-to-day job is the key to making the needed improvements to our processes. If you get an opportunity, become involved with an RIE to see how it works. Getting the Air Force community to think CPI and having it become second nature is a major goal of AFSO21.

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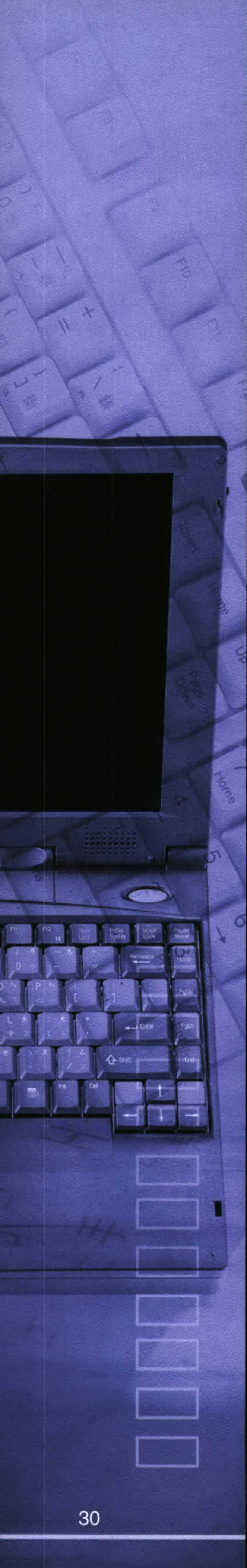

Captain Dan Henderson, USAF

AFSO21 Continuous Process Improvement

Management Tool

The Continuous Process Improvement-Management Tool system is a common access card-only enabled Web-based system, utilizing the Air Force Portal for its security boundary. Currently access to the system is granted by major command-, base-, or wing-level AFSO21 offices. There are over 3,500 users in the system, with nearly 1,300 having permissions to enter new or edit existing projects in the system.

Introduction

As the Air Force started the enterprise rollout of Air Force Smart Operations for the 21st Century (AFSO21), a requirement existed for a secure, Web-based, searchable and collaborative information technology tool that could not only provide a central repository of AFSO21 events for use in the field, but also could quickly roll up information for higher-level reporting. The AFSO21 office chose a commercial-off-the-shelf software solution, PowerSteering, from PowerSteering Software, Incorporated.

As the Air Force originally configured and implemented the software, it was designed to provide Air Force key process owners, major commands (MAJCOM), Air Force key process owner core teams, wing AFSO21 offices, problem solving team leaders, and problem solving team members with the following:

Air Force Smart Operations in action

- **Project Management.** Create, manage, analyze, process, control, and report process improvement project information
- **Strategic Alignment.** Align process improvement projects to Air Force key processes
- **Executive Visibility.** Provide management dashboards for enterprise awareness
- **Reporting.** Provide an automated report delivery system
- **Idea Portal.** Provide the capability to submit suggestions for review of AFSO21 events, which could be turned into chartered projects

A heavy emphasis was placed on the project management component, and a formalized *gated* (approval) process was used to enter and track AFSO21 projects. However, recent *voice-of-the-customer* feedback has resulted in changes to this configuration, and a *non-gated* basic work template is now available in the system, allowing users to quickly enter information without having to utilize a formal approval process for AFSO21 events.

The AFSO21 office, in consultation with PowerSteering Software, developed a set of seven user-level computer based training (CBT) modules, each of which is less than 10 minutes in length. The CBTs allow a new user to quickly and sequentially go through training, which includes everything from a basic system overview, to entering a new AFSO21 project, to detailed reporting and collaboration capabilities. This modular approach also allows a user to go through *on-the-fly* refresher training for any particular component of the system.

System Overview

The Continuous Process Improvement-Management Tool (CPI-MT) system is a common access card-only enabled Web-based system, utilizing the Air Force Portal for its security boundary. Currently access to the system is granted by MAJCOM-, base-, or wing-level AFSO21 offices. There are over 3,500 users in the system, with nearly 1,300 having permissions to enter new or edit existing projects in the system.

The CPI-MT system allows AFSO21 projects or events to be tracked in a work tree structure that is similar to using the common Microsoft Windows File Explorer. However the AFSO21 work tree structure is aligned both organizationally and by the 10 Air Force key processes. This allows individual units, aligned under their organizational structure, to enter AFSO21 projects or events under their MAJCOM. Each MAJCOM AFSO21 office has administrative control over its users and the projects under its MAJCOM. For AFSO21 events that have Air Force-wide impact, impact multiple MAJCOMs, or are better tracked by the process owners, those events are stored in the 10 Air Force key processes portion of the CPI-MT work tree. As with the MAJCOMs, the Air Force key process owner core teams have full administrative control of their users and their portion of the AFSO21 work tree.

Each MAJCOM was provided great flexibility in the structure of the work tree. Some MAJCOMs chose to keep an organization (base or wing) type structure for entering and storing information, while others chose to use a process-based approach, based upon MAJCOM strategic alignment and deployment priorities.

Numerous and powerful reporting capabilities are available *out-of-the-box*, both visually and in electronic formats. Numerous reports are available in PDF, Word, Excel, and Hypertext Markup Language formats. Hard copy reports can also be set up to automatically run at specific intervals and the results e-mailed in the desired format to multiple users. A visual dashboard is available to graphically see the results and progress of AFSO21 events and can be configured to the individual user. Dashboards can be developed to brief senior leadership direct from the CPI-MT system, without having to create separate PowerPoint-based briefings. However, for those who desire to use PowerPoint, a PowerPoint slide builder is also included in the CPI-MT system.

The built-in e-mail, document repository, and collaboration capabilities of CPI-MT allow the system to be a central location for everything connected with an AFSO21 event. From a document perspective, many common document types (such as PDF, Word, Excel, PowerPoint, Visio, Microsoft Project) can all be stored and added to an AFSO21 project. Documents may even be *checked out* and updated, ensuring multiple versions of the document are not being edited at the same time. The collaboration capabilities of the software are a powerful feature, allowing discussion threads to be started on items. These discussion threads can be elevated to issues, or even individual action items can be created and assigned to specific individuals. This collaborative environment ensures that all the relevant information and discussions associated with an AFSO21 project or event are stored in an easily

searchable central repository for permanent storage and long-term retrieval.

In addition, the CPI-MT system has a powerful search capability that allows users to do a basic search based on people or project and event titles, or conduct an advanced search that will look through stored documents and detailed project information.

Air Force Maintenance for the 21st Century (AFMx21) Usage

The original *Air Force Maintenance for the 21st Century (AFMx21) Implementation Plan* utilized an extensive Microsoft Excel spreadsheet that was the blueprint for implementation and the mechanism for tracking progress in completing tasks and subtasks related to achieving the goals and objectives of the *AFMx21 Strategic Plan*. As the implementation plan progressed and evolved, maintaining that spreadsheet became an onerous and man-hour intensive process. Additionally, efforts to Web-enable the *AFMx21 Implementation Plan* met near insurmountable information technology, security, and access restrictions in attempting to develop a stand-alone AFMx21 implementation application.

In lieu of developing an independent Web-enabled implementation application, Headquarters US Air Force Directorate of Logistics, Installations, and Mission Support, Maintenance Division (AF/A4M), approached the AFSO21 office about using the CPI-MT system for tracking and reporting of the AFMx21 implementation, project completion and transformation progress. This resulted in a new section in the AFSO21 CPI-MT work tree dedicated to AFMx21. This couples AFMx21 implementation progress with the AFSO21 business processes for managing transformation. In addition, the powerful document management capability, report generation, progress tracking, and automatic message generation were all key features that led to the decision to utilize the CPI-MT system.

The implementation plan data was loaded into CPI-MT by the AFMx21 office. A detailed users' guide was developed for Air Force Maintenance Advisory Group members, offices of primary responsibility, offices of collateral responsibility, and individual task owners. The guide provides instructions for accessing, updating, amending, and creating AFMx21 implementation tasks and subtasks. By using the AFSO21 CPI-MT application, AFMx21 implementation plan tracking uses the CPI-MT application terminology, business processes, and templates. While some unique AFMx21 modifications were necessary, generally the standard CPI-MT terminology is used throughout.

Upcoming System Enhancements

The most significant change expected to the CPI-MT application is making the vast information stored in CPI-MT available to any Air Force Portal user. Work is currently underway with PowerSteering Software to allow any Air Force Portal user to *self-register* in the CPI-MT system, as a *read-only* user, without requiring any intervention from the MAJCOM, base, or wing AFSO21 office. This update, expected in the fall of 2008, will greatly increase the knowledge sharing capabilities of the system, allowing more Air Force users to search the central repository of AFSO21 projects and events.

Work is also ongoing to allow the MAJCOMs, 10 Air Force key processes and AFMx21 to each develop a standardized portfolio, which would enhance the ability to allow all similar users to see data in exactly the same way, every time they access the system.

Finally, the AFSO21 office is exploring the possibility of making the CPI-MT database searchable from external sources, perhaps directly from the Air Force Portal or Air Force Knowledge Now. This would greatly increase the capability to ensure AFSO21 information is readily available to any individual who desired it.

Captain Dan Henderson is assigned to the Global Operations Center, Integration Branch, United States Strategic Command, Offutt Air Force Base, NE. At the time of the writing of this article, he was the Branch Chief, Information Technology, Secretary of the Air Force, Office of Smart Operations for the 21st Century.

No form of transportation ever really dies out. Every new form is an addition to, and not a substitution for, an old form of transportation.

—Air Marshal Viscount Hugh M. Trenchard, RAF

Air Force Smart Operations in action

AFSO 21 Problem Solving

The Process and Related Tools

Paul A. Dunbar, USAF
Lieutenant Colonel Joseph Heilhecker, USAF

We have learned and grown in our continuous improvement understanding as we have implemented Air Force Smart Operations over the past few years. Early efforts were largely oriented around conducting rapid improvement events (RIEs), which are an effective tool but an incomplete approach to problem solving. Early AFSO21 facilitator training was also largely focused on planning and facilitating a group through an RIE.

Our current AFSO21 training for facilitators (Level 1 and 2), leaders, and Airmen orientation, as well as the *AFSO21 Playbook*, have changed to put greater focus on structured problem solving with RIEs being one of several useful tools. Problem solving events range from *just do it* actions to large process reengineering initiatives. The AFSO21 problem solving structure is scalable to the type problem being addressed by a team or individual.

What follows is the Air Force Observe, Orient, Decide, Act (OODA) 8-Step Problem Solving model (see Figure 1, page 36). Within it is a structured, and recognizable, 8-step sequence Airmen are being trained to use. The OODA cycle is one that would be repeated in the course of continuous process improvement (CPI). It is a cycle analogous to Deming's *Plan, Do, Check, Act*, but fit to our Airmen's culture and language.

The first steps of the OODA model are critical, ensuring the right problems are being addressed and align with local leadership priorities. These steps will help teams or individuals think critically about why a particular issue should be addressed. They will help one answer a question that should be asked by their leaders or external stakeholders, Of all the problems you could have attacked, why this one?

The next set of steps requires improvement targets be set and the true root causes be identified. Next, countermeasures need to be set and followed through as part of the Act stage of OODA. The last two steps are accomplished to confirm the achievement of desired results and to

standardize the successful process improvements. The last step is most often skipped but is critical to the never-ending cycle of continuous improvement using OODA. Unlike an extra helping of dessert, don't skip it!

Following the sequenced actions in the 8-step methodology will help teams ensure they do not jump to improvements and countermeasures to problems prior to understanding the problem and root causes. Following the eight steps will ensure the results are aligned with the needs of the organization. All of this leads to a coherent nesting of organizational purpose and activities, as well as a virtuous cycle of continuously improving organizational and Air Force capability.

Readers will find additional information on the 8-step methodology in the *AFSO21 Playbook*. The playbook is accessible at the *AFSO21 Knowledge Area* within *Air Force Knowledge Now* on the Air Force Portal at the following URL: https://rso.my.af.mil/afknprod/ASPs/CoP/FuncCoP.asp?Filter=OO-21. Select the CPI Resource Center icon to access the playbook and many other helpful AFSO21 materials.

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Lieutenant Colonel Joseph Heilhecker *is currently the Deputy Chief, Integration Division, Air Force Smart Operations. He was instrumental in the successful introduction of Smart Operations into the KC-135 depot line at the Tinker Air Logistics Center.*

Observe, Orient, Decide, and Act
8-Step Problem Solving Model

1. Clarify and Validate the Problem. O O D A

Identifying and clearly defining a problem is critical. Only after a problem is completely understood is the team in the best possible position to solve the problem.

a. Does this problem, when solved, help meet needs identified by the organization?
    - Is it linked to the SA&D of organization?
    - Does it help satisfy customer needs?
b. Does this problem, when solved, address key issues identified during SWOT analysis?
c. Has this problem been identified and directed by a value stream map at the appropriate level?
    - What does the future state need?
    - What resources have been identified to address this issue?
d. What opportunities were identified or observed by the process or problem area walk?
    - Will addressing or improving these issues deliver results that relate to item a or item b?
    - Will addressing or improving this problem deliver the desired future state from item c?

2. Break Down the Problem and Identify Performance Gaps: O O D A

The first step in assessing a problem area is gathering and reviewing key process indicators (KPI) and metrics. Understanding what objective data is needed and what the data, once it has been gathered, means is critical to root cause problem solving and process improvement.

a. Does the problem require more analysis or does leadership have enough information to execute a solution?
    - Is this simply a leadership directive?
b. If more data is needed, how do we measure performance now?
    - What are the KPIs? What is the performance gap?
c. Does other data need to be gathered?
d. What does the data indicate are the potential root causes?
e. Does the data review indicate a bottleneck or constraint?

3. Set Improvement Target: O O D A

Improvement targets must be set on two levels simultaneously; the strategic and the tactical. At a high level, the Air Force leader must create a vision of what the organization will strive to become. Tactical targets define the performance levels required to make the vision a reality.

a. Is the improvement target measurable? Is it concrete? Is it challenging?
b. Is the target output oriented?
    - What is the desired output?
    - Should be things to achieve; should avoid things to do
        - o Will be addressed by action plans (Step 5)
c. The desired target should:
    - Do what? By how much? By when?
d. If it is a process problem, what is the future state?
    - How will it be realized?

4. Determine Root Cause: O O D A

Root cause analysis is a trade-off between digging as deeply as possible, and finding the deepest point that is still within the team's sphere of influence.

a. What root cause analysis tools are necessary?
    - Why are these tools necessary?
    - What benefit will be gained by using them?
    - Who will need to be involved in the root cause analysis?
        - o Ten heads are better than one
        - o Remember cultural issues related to problem
b. What are the root causes according to the tools?
c. How will the root cause be addressed?
d. Will addressing these address the performance gap?
e. Can the problem be turned on or off by addressing the root cause?
f. Does the root cause make sense if the Five Whys are worked in reverse?
    - Working in reverse, say therefore between each of the whys

5. Develop Countermeasures: O O D A

The key principle to remember is that the impact of a solution is a combination of the quality of the solution and the acceptance of the solution by the people who must implement it.

a. Develop potential countermeasures
    - Tools and philosophies from Lean, Theory of Constraints, 6 Sigma, and Business Process Reengineering as appropriate.
b. Select the most practical and effective countermeasures
c. Build consensus with others by involving all stakeholders appropriately
    - Communicate, communicate, communicate
d. Create clear and detailed action plan
    - B-SMART actions
    - Reference facilitation techniques as appropriate

6. See Countermeasures Through: O O D A

Action comes at the end of the OODA Loop for a reason. Air Force leaders acting before they are ready for this step are likely to be as successful as the marksman with the motto ready, fire, aim.

a. Which philosophy best prescribes tools that address root causes?
b. Which tools best address root causes?
c. Which method for implementation fits the tool and improvement need?
    - Rapid improvement event (RIE)?
    - Improvement project?
    - Point improvement or Just Do It?
d. If RIE or project, create charter and communicate
e. What training or education is needed? By whom?

7. Confirm Results and Process: O O D A

This step closely mirrors the data collection portion of Step 2. Ideally the KPIs and metrics identified in Step 2 will be all that is needed here.

a. How are we performing relative to the Observe phase (Steps 1 and 2)?
b. How are we performing relative to Step 3?
c. How are we performing relative to financial reporting template projections?
d. If we are not meeting targets, do we need to return to Step 4?
    - Most problem solving breakdowns occur relative to improper root cause identification

8. Standardize Successful Processes: O O D A

This is the most commonly skipped and under-completed of the entire problem solving process. It is very tempting to take newfound knowledge and skills and immediately move on to the next improvement initiative, skipping the effort of ensuring the results stick.

a. What is needed to standardize improvements?
    - Tech order changes?
    - Air Force instruction changes?
    - Official instruction changes?
b. How should improvements and lessons learned be communicated?
    - CPI-Management Tool (PowerSteering)
    - Key meetings?
c. Were other opportunities or problems identified by the problem solving process?

Figure 1. Observe, Orient, Decide, Act 8-Step Problem Solving Model

Air Force Smart Operations **in action**

T56 Engine Line—Little Rock AFB

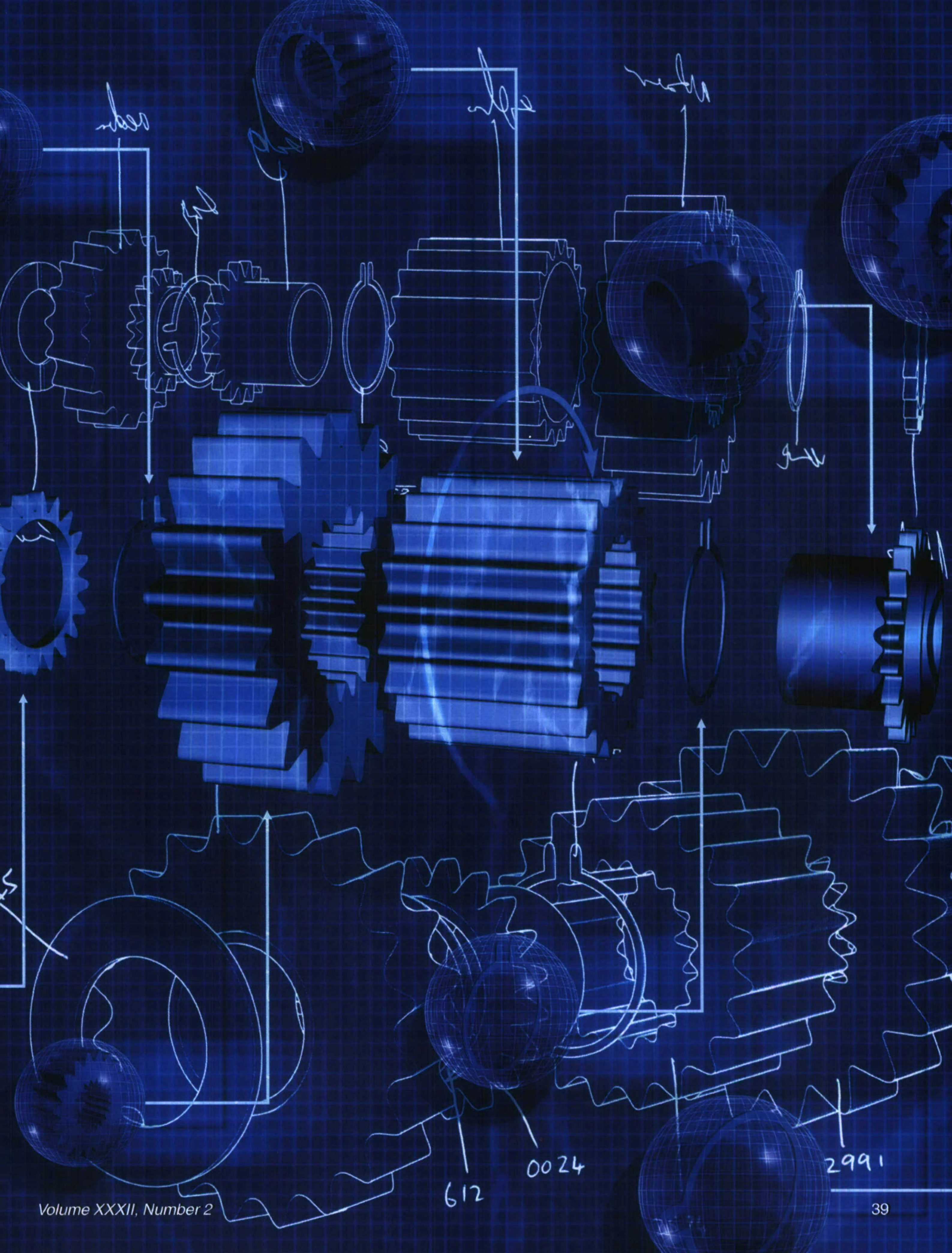
Successes and Challenges

In 2006 the Engine Regional Repair Center (ERRC) set out to deliver T56 engines faster, with more precision, and using fewer resources by applying the key principles of Lean manufacturing as a part of Air Force Smart Operations for the 21st Century (AFSO21). Our initial goal was to increase efficiency 30 to 40 percent—meeting engine demand 100 percent of the time.

Colonel Jeffrey Hoffer, USAF
Lieutenant Colonel David Haar, USAF
First Lieutenant Nicole Hagerman, USAF

Introduction

The 463d Airlift Group's ERRC provides regional T56-A-7B/-15 Jet Engine intermediate maintenance for Air Mobility Command's (AMC) C-130 units at Little Rock, Dyess, and Pope Air Force Bases (AFB). The ERRC was first established in 1996 with a 54-man contract field team (CFT). In 1998 the CFT handed supervisory control over to the Air Force. Since then, the ERRC's concept of operation has incorporated training and developing assigned Air Force personnel with increased propulsion system troubleshooting and maintenance skills. Although senior Air Force enlisted members help develop new Airmen through their usual supervisory roles, much of the training is actually completed by tapping into the CFT's extensive expertise. These CFT members have over 20 years of experience with the C-130 weapon system and pass along this experience to the new Airmen. Furthermore, the CFT supplies a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solid foundation for engine repair while their military counterparts support AMC deployment commitments. Today we have 58 authorized Air Force personnel and 38 CFT members.

The ERRC is unique in a number of ways. For example, there is a special authorization for system engineers that allows the center to perform specific depot level maintenance repairs, saving thousands of dollars annually. Another example is the center's use of reliability-centered maintenance practices and estimated time-on-wing calculations as a baseline to produce more reliable engines. The only other repair facility comparable to the ERRC is the Lockheed Martin/Kelly Aerospace facility located in San Antonio, Texas.

Our Journey on the Air Force AFSO21 Path

In 2006 Air Force and contractor personnel at the ERRC embarked upon a journey of continuous process improvement. The ERRC set out to deliver T56 engines faster, with more precision, and using fewer resources by applying the key principles of Lean manufacturing as a part of AFSO21. Our initial goal was to increase efficiency 30 to 40 percent—meeting engine demand 100 percent of the time. The overarching goal within the ERRC remained—continuously improve, and make a *good* process a *great* process.

Pre-AFSO21

Members of the ERRC embarked on their AFSO21 journey by identifying the most apparent areas of waste:

- Engine production was based on the crew buildup structure
- Erratic output, nonstandard work, and sharing of special tools and equipment
- No visual cues built—either visual management or controls in place
- *Push system* production—high inventory buildup and over production
- Section isolation—disconnected from the overall engine production flow
- Section takt times nonexistent or synchronized
- Extensive unnecessary travel to and from a composite tool kit section
- Maintained significant excess work-in-progress
- Shop floor layout reflected disarray and excessive work travel distances

Instilling the AFSO21 Culture

To eliminate or reduce the above mentioned waste, change and innovation had to be encouraged through the use of AFSO21. The tools and techniques of the AFSO21 methodology were viewed as a continuous effort versus a one time, short-run effort. Each person came to accept the concept of continuous improvement. It was evident the desire to control one's own destiny by recommending and making changes was spreading from person to person and work area to work area until the entire shop was on board and hungry for more.

The tools and techniques of the AFSO21 methodology were viewed as a continuous effort versus a one time, short-run effort. Each person came to accept the concept of continuous improvement. It was evident the desire to control one's own destiny by recommending and making changes was spreading from person to person and work area to work area until the entire shop was on board and hungry for more.

AFSO21 to Present

From 2006 to 2008 great progress was made toward a more efficient process. Production efficiency increased 30 percent by applying basic AFSO21 methodologies. The following are examples of past findings and initiatives.

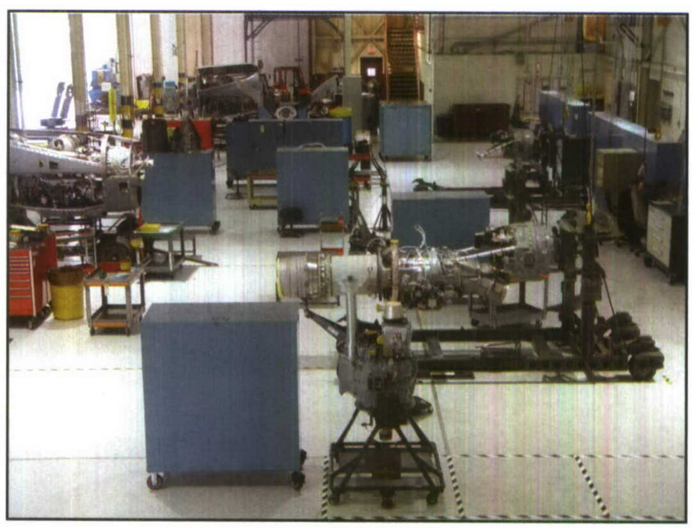
- Designed and implemented a new, single item flow process, which eliminated batches of products waiting

in the queue. Reinforcement and self-discipline in this standard work provided for sustainable and predictable production output.

- Relocated toolboxes closer to the workstations. Technicians travel for specialty tools only. These tools require stricter controls due to calibration requirements or other restrictions.
- Established a *supermarket* of inventory items controlled and used in production at an upstream process. This is a designated area on the shop floor, close to the technician, where items are stored until installation. This concept promotes the *just-in-time* concept—having what is needed, only when it's needed. Because of its high visibility, an empty area triggers the need to replenish an additional part (subsystem).
- Created a hazardous material locker within the work area—reduced walking and waiting in line for chemicals in the composite tool kit section.
- Created a bench stock list for lockers with necessary hardware—reduced time spent walking, waiting, and searching for hardware at bench stock carousels.
- Segregated lockers into A, B, and C shelves to coordinate with the assembly line cells, enabling the technician to immediately view all components and hardware for tasks to be performed.
- Arranged work packages for inspection, repair, and buildup flow, creating an organized and orderly process which allows the technician to know what needs to be done next.
- Developed a quick engine change (QEC) kit locker, allowing the technician to have all necessary components and hardware needed for a QEC kit buildup at his or her station—eliminated walking, waiting and searching for hardware in bench stock carousels.
- Realigned sheet metal technician duties—organized technicians into teams for lower QEC kits and reduced large batches of end-item products and long waits.
- Repositioned work cells to synchronize production flow.
- Visual production management and control boards were implemented, allowing management to view all engine and module production status.
- Implemented error-proofing picture books.
- Established *6S* efforts.

In late 2007, Dr Ron Ritter, Special Assistant for Air Force Smart Operations to the Secretary of the Air Force, highlighted the ERRC as *The model T56 propulsion enterprise for the Air Force.* Members of the ERRC were tasked to establish a 6-month plan to develop the optimum shop design and processes for T56 engine and propeller repair. This model would be detailed enough for potential deployment enterprise-wide. To date, numerous activities have occurred, including two significant rapid improvement events (RIE). These events consisted of a high-level value stream map (VSM) to identify the interactions of all propulsion functions. This floor plan is intended to guide our followup events for the next few months. Each followup event will develop a particular repair line and the physical layout of each cell within the repair line. Personnel assignments and standard work are to be based upon takt and cycle time. As predicted, the second event (Assembly line [or A-line] and Test Cell RIE) did just that for the A-line and contributed to the VSM for the engine test cell process. Although our journey has proven successful, we have encountered many

ERRC Prior to AFSO21



ERRC in the Final States of AFSO21

challenges and foresee more to overcome. (See Figures 1 and 2 for the future and ideal states)

Our Challenges

Communication

It is one thing to simply state that communication is key, and quite another to elevate it to the level of daily reinforcement it requires. With this in mind, communication continues to be the most critical challenge. There are a myriad of stories to communicate to the various entities involved in the ERRC's development; however, there are few sustainable opportunities by which to communicate these stories. The deployment of any effort with the magnitude of the propulsion enterprise and the potential impact upon the Air Force, demands the use of every conceivable communication tool. There are multiple levels of communication (coordination, information sharing, and approvals) required to keep all individuals within the ERRC up to date. This may seem like an easy task; however, it was harder than expected. Many discussions and decisions were made within the inner workings of an event that did not always get communicated to the floor. We found the easiest way to communicate to those individuals was through the event members themselves and not so much through the leadership team. Mid-level communication was keeping our group up to date on initiatives and barriers via the monthly AFSO21 Executive Council Meetings. Now that our internal engine AFSO21 project has become an Air Force-level enterprise effort, communication in all directions has become more rigorous. Currently we have biweekly gate reviews with our team lead and have proposed monthly gate reviews with Secretary of the Air Force, Smart Operations (SAF/SO); Headquarters Air Force, Deputy Chief of Staff, Logistics, Installations, and Mission Support, Maintenance Directorate (AF/A4M); and Headquarters Air Mobility Command, Logistics Directorate (AMC/A4). Sustaining these meetings requires constant coordination and becomes

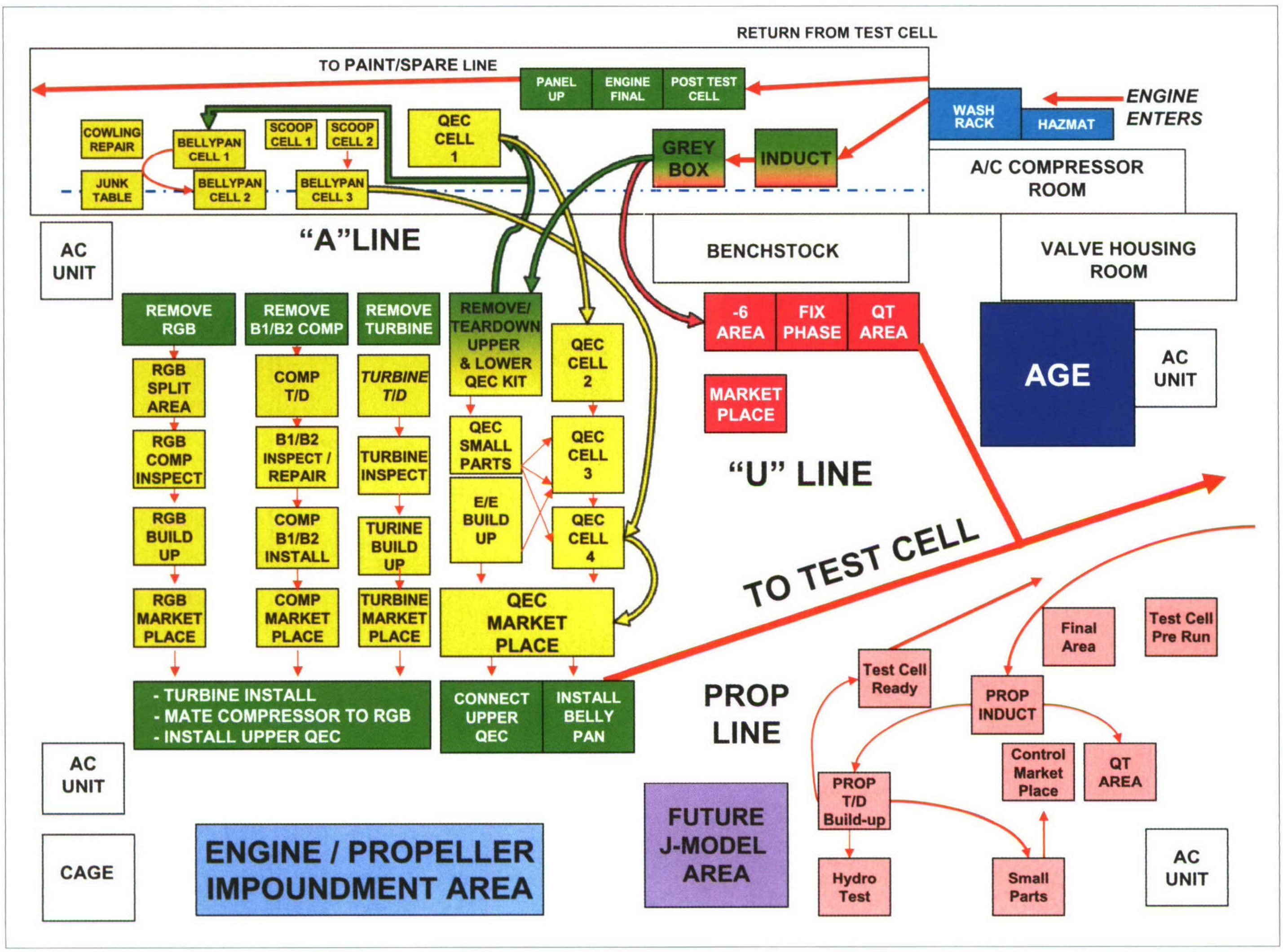


Figure 1. Future State

complicated, competing for time with day-to-day operations.

Knowledge Management, Personnel, and Turnover

The CFT provides a wealth of knowledge; however, as the contractors leave the workforce they take with them vast amounts of experience and knowledge. The military workforce is continually changing with younger, inexperienced Airmen replacing CFT members. If great care is not taken to capture the vast contractor knowledge base, we will dramatically limit our ability to improve and not benefit from historical lessons learned. In an ideal world, the Air Force manpower system would take these manning challenges into account and provide replacements who have similar experiences and training. Unfortunately, this is not always the case and the practical experience gained by working within the ERRC is often lost. Military members are subject to the same long-term challenges as our CFT members—retirement, relocation, as well as activities the CFT does not contend with such as deployment, career development and training absences, and others. To compensate for the manning changes and disruptions, the team has begun developing new training tools and new software programs that allow us to collect huge amounts of information and research in a very short time.

Time

Time constraints will continue to be one of the greatest challenges. Several RIEs and 6S efforts were completed, and many more are scheduled in the future in order to complete establishing the model T56 engine line. Five improvement events have been completed to date, each of which has taken the standard week to accomplish. However, the administrative burden has required personnel to be taken *out of hide* in order to consolidate, focus, and maintain data. The T56 engine project has significantly benefited from part-time expert

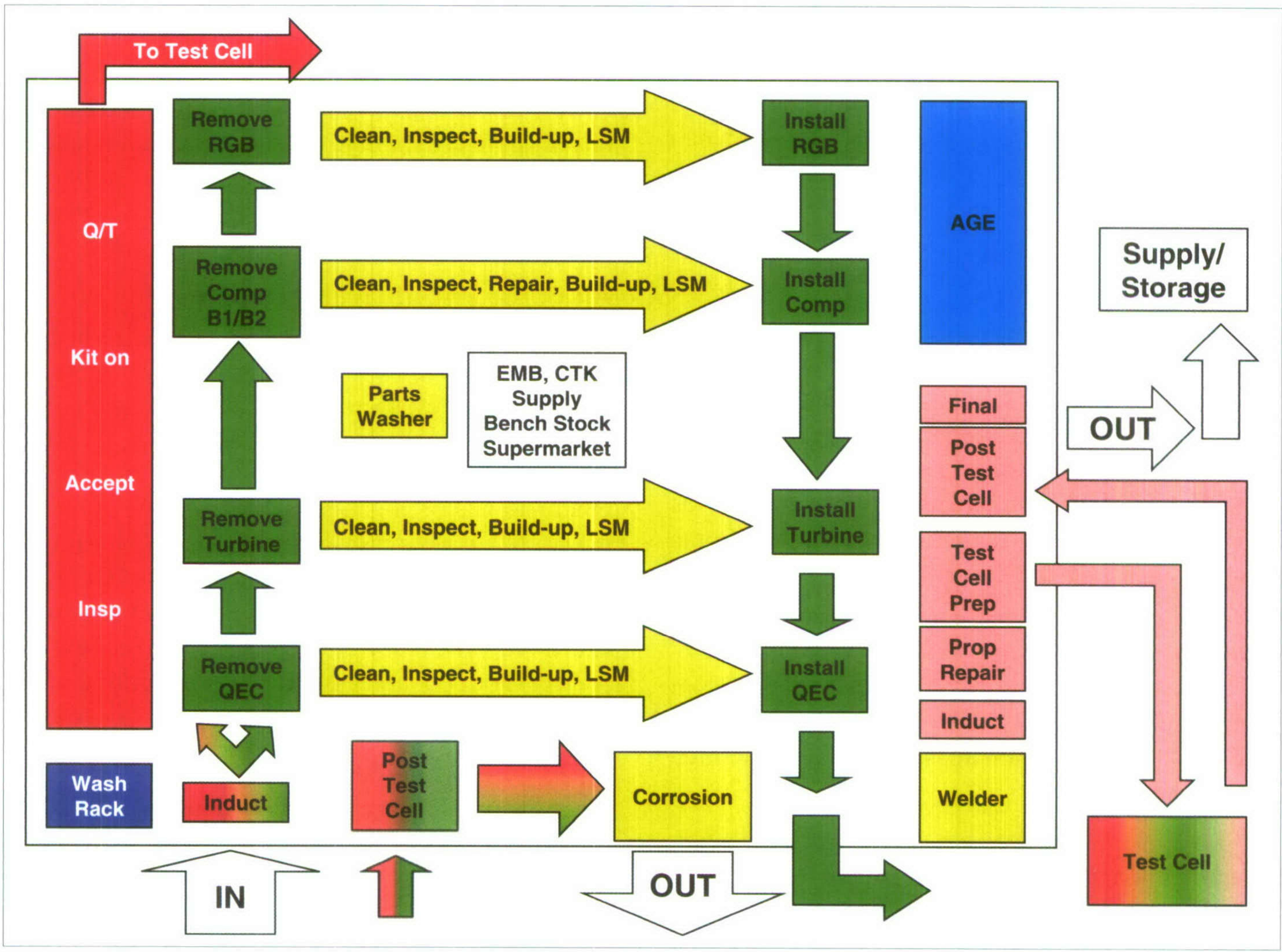


Figure 2. Ideal State

consultant support to help guide us with overall efforts. This support provides an outside-the-Air-Force, industry perspective, and helps our team maintain both its focus and intensity.

To overcome time and personnel limitations, success has been achieved through the scheduling and goal setting process. Once the 6 month project surge began, it became absolutely critical to establish the project's pace and priorities, and to build a comprehensive schedule agreed upon by all team members.

The schedule was revised at several points because of unforeseen limitations and time to coordinate throughout the enterprise. Multi-agency coordination can be a daunting task; however, once achieved the momentum gain was impressive. It took several months to coordinate the first working-level meeting intended to encompass the entire enterprise. This was a communication opportunity and a truly demanding challenge; however, persistence prevailed and the result was a successful meeting and exchange of information. The entire enterprise was brought together in a single forum—invaluable discussions culminated in a greater understanding of the opportunities and constraints ahead. The time taken to bring the team together has improved our latest events. Air Force Special Operations Command members have become essential, supporting each of our events with experts and providing valuable input into the construction of the model engine line.

Manpower Reductions

AFSO21 (and more to the point Lean) is not an acrostic for *fewer employees are needed*—although ideally, it does cut the waste that sometimes leads to workforce realignment. Instead, Lean looks at manpower inefficiency and capital resources producing nonstandard work. Nonstandard work found was unnecessarily bound by illegitimate constraints. Some examples of nonstandard work include:

- Repeat quality problems causing additional quality and 7-level inspections.
- The development of local procedures to apply more stringent controls, resulting in additional manpower to monitor the program and to maintain the written procedures.

With the implementation of recent DoD-wide manpower reductions, Lean tools were instrumental in highlighting this kind of waste, as well as other waste driving the research, study, and implementation of viable alternatives.

Building Synergy

Synergy within the project will remain a challenge as it moves forward, and as greater demands are placed upon the people to identify the next set of innovations or improvements. Synergy is built by demonstrating a desire to hear and discuss all possible solutions or opportunities, and by including as many people as possible in team events. The project will not wait until every person can participate in a team; however, every opportunity is taken for open discussion.

Competing Wing Resources

Manpower reductions are not the only events that impact a unit's resource picture. Air Force requirements such as the Global War on Terror (GWOT) and the subsequent deployment of qualified technicians to support GWOT operations have also created obstacles to production. In addition, other traditional Air Force duties such as the physical fitness program, training requirements for all skill levels, and various *details* take their toll. Fortunately, we have a workforce that also consists of contractors who work side-by-side with the Air Force members and is able to step in as needed. In order to manage these constraints, visual controls were established using a production manning board. The information on this board provides a quick reference to the availability and training level of an employee. Management is then able to adjust personnel assignments based upon the known availability of the employee.

Air Force Priorities and Support

To establish the Air Force's model T56 engine line, the project must compete at the Air Force level for priority and dedicated resources. It must demonstrate its value competing against such activities as GWOT, recapitalization of the Air Force's weapon systems, and other national or global considerations. AFSO21 and the use of business case analysis tools help the project compete. In addition, the project was selected for review at the Air Force 4-Star Process Council. Leadership and executive oversight has been critical to keeping this project on track, and essential when working at the enterprise level.

Too Far Out Front?

Once the model engine line is built and ready for deployment, management of this engine repair node will require repair network transformation (RNT) management support. The propulsion enterprise repair model can be deployed and implemented as the first Air Force enterprise tool— essentially a *plug and play*

concept for other engine types and repair facilities to follow. This RNT-managed deployment will be able to achieve far-reaching versus localized efficiencies. We foresee customer demand being the driver versus a traditional adding or subtracting *X percent* for out-year production goals. The propulsion enterprise concept potential is enormous, perhaps extending to all DoD repair facilities.

Conclusion

Our success, to date, has been fraught with conflict and frustration, with equal amounts of excitement and satisfaction mixed in. However, one thing is clear, from 2006 to 2008 production efficiency increased 30 percent by applying basic AFSO21 methodologies.

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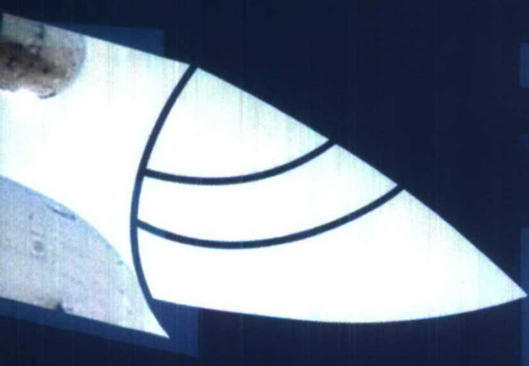
***Colonel Jeffrey Hoffer** is the Group Commander, 463d Airlift Group, Little Rock AFB, AR. Colonel Hoffer is a previous contributor to the Air Force Journal of Logistics.*

Air Force Smart Operations in action

AFSO21 and the 6th Maintenance Group

Reconceptualizing Maintenance Practices



The group remains focused on AFSO21 for several reasons. First, it is a way for Airmen at all levels to rethink and engage the day-to-day waste inherent in all our processes and make continuous improvements. It is critically important to obtain buy in at all levels to ensure this will not become a passing fad. Next, Airmen recognize that leadership is serious about implementing the changes they suggest. Third and most important, leadership is given a tool to reduce workload on their troops. We've cut 2.5 work days off the #2 Periodic Inspection and reduced the duty day from 12-hour shifts to 10 hours. Our goal is to slash another 2 days and an additional 2 more duty hours per day per troop to get our folks *back* to a normal duty day and still roll out a quality product.

Colonel James C. Howe, USAF
Captain John E. Creighton, USAF

Introduction

In today's environment, MacDill Air Force Base, like many other bases, continues to experience budget pressures, personnel reductions, and time constraints. Downsizing and base realignment and closure commission initiatives have significantly strained our capabilities to sustain home station missions as we continue to support a high operations tempo in the Global War on Terror.

In 2005, the Secretary of the Air Force and Chief of Staff issued clear direction to implement Air Force Smart Operations for the 21st Century (AFSO21). Leaders in the logistics arena stressed more efficient use of logistics resources through two major initiatives: implementing aircraft

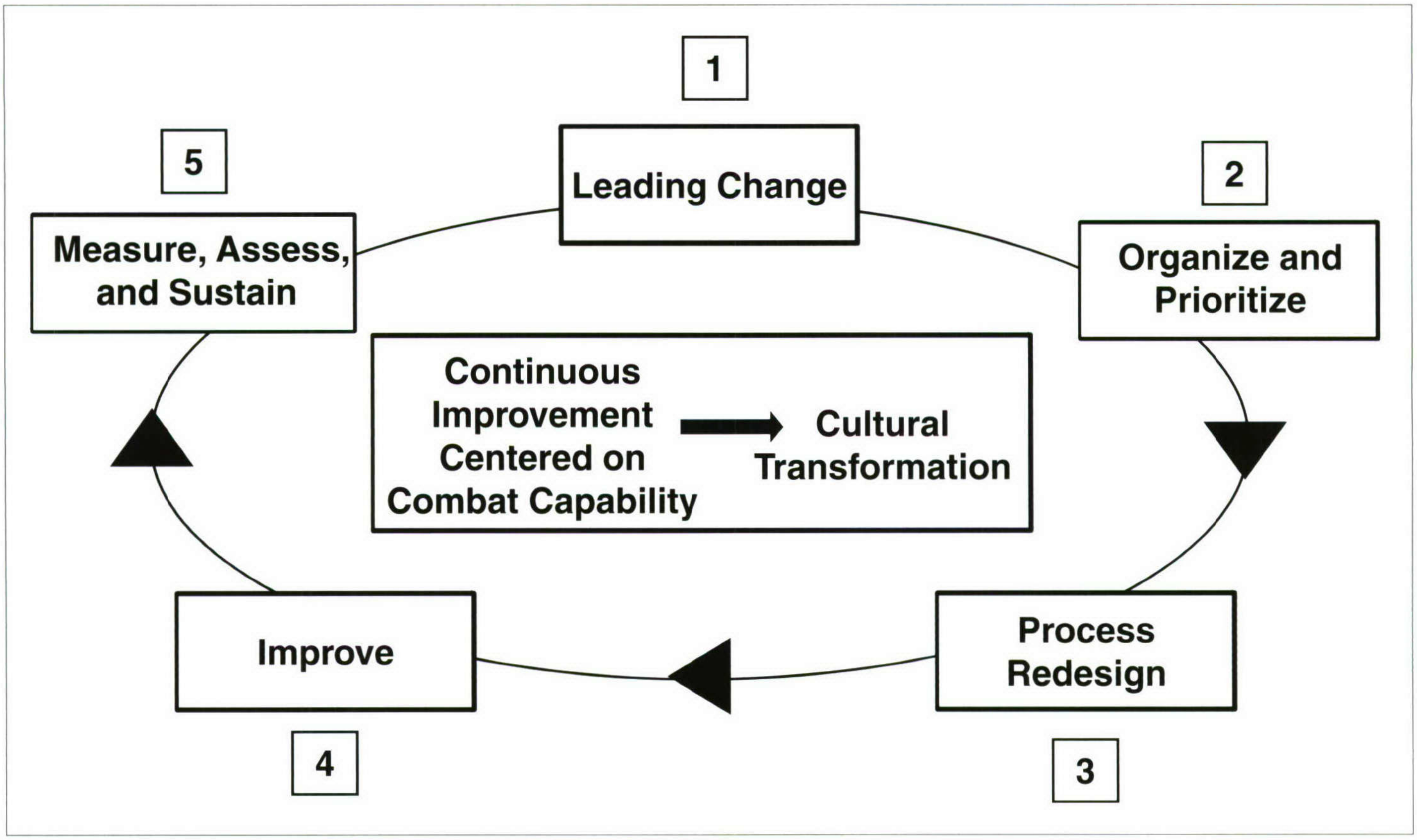


Figure 1. Model for AFSO21 CPI

availability improvement programs and institutionalizing Lean concepts throughout logistics organizations (see Figure 1).

The call for AFS021 continuous process improvement (CPI) and the need for transformation challenge us to look for more efficient ways to do business. We must become more combat effective while on the journey and remain focused on our Air Force priorities: *Win Today's Fight, Take Care of Our People, and Prepare for Tomorrow's Challenges.*

In addition, multiple deployments, rapidly developing technology, and supply chain management enterprise globalization have created hyper-work (24 hours per day) environments which are ripe for CPIs and transformation. These environments present unique challenges to Air Force Airmen regardless of echelon of command. Air Force leaders at all locations must lead the charge to change how we think about and perform our business—organizational- and intermediate-level maintenance.

The 6th Maintenance Group (6 MXG) has embraced the culture of AFSO21. Airmen throughout the group have experienced significant benefits from various AFSO21 projects first hand. The group standardized work practices and improved major maintenance processes throughout the maintenance complex. These improvements have positively impacted the wing and mobility air forces (MAF) KC-135 aircraft availability. Rapid improvement events (RIE's), standard work evaluations, 6S (sort, straighten, shine, standardize, sustain, and safety), Gantt charts, and visual work space projects are all words which are now part of the daily language of the group.

Initiatives

Headquarters Air Mobility Command, Directorate of Maintenance, encouraged its KC-135 maintenance group deputy commanders to form a *Council of Deputies* (COD) and empowered them to implement AFSO21 initiatives across the command. The 6 MXG volunteered to tackle the aircraft transfer process which was identified as a proposed improvement area from the initial COD conference held at McConnell Air Force Base (AFB) in January 2007. Airmen from 6 MXG have also refined the aircraft quick turn process and turned the fuel cell trainer initiative into a reality. Both efforts could potentially become standard work practices across the KC-135 community.

In addition, this past January, the 6 MXG partnered with the 319 MXG (located at Grand Forks AFB, ND) to host the #2 Periodic Inspection (PE) project for the KC-135. This ground breaking event went from an RIE

to a project with 49 *just-do-its* and 30 follow-on projects, all catalogued in the community of practice Website—more on those results later.

The 6th Maintenance Squadron (6 MXS) proposed two manufacturing initiatives: the OMAX water jet cutting machine and the Global Local Manufacturing Factory Initiative (GLMFI)—both of which offer potential Air Force-wide benefits. Our most recent project is tackling the corrosion control aircraft wash process, which is exacerbated by the highly corrosive Florida environment.

These initiatives are just a few examples of processes, concepts, and maintenance practices that the highly motivated Airmen of the 6 MXG have evaluated and are continually working on improving. Our AFSO21 successes are challenging, but well worth the effort. The 6 MXG's first event, the aircraft transfer process, demonstrates the benefits of AFSO21.

From 30 April through 4 May 2007, the 6 MXG led a MAF-wide KC-135 Aircraft Transfer RIE. The goals were to standardize work, reduce man-hours and ultimately increase KC-135 aircraft availability to the warfighter. MacDill AFB is located in a severe corrosion environment, which drives an abridged aircraft rotation program between bases every 24 months. This nonstandard process required 72 hours to accomplish, but more importantly took the aircraft *out of the fight* for 3 days.

This initiative was a huge success. It resulted in a standardized 18-step checklist, which now only takes 24 hours to accomplish and saves 60.8 maintenance man-hours per aircraft transfer. Currently, the KC-135 Weapon System Manger at Headquarters Air Mobility Command (HQ AMC) is working with counterparts at Tinker AFB, OK (KC-135 depot) to incorporate these steps into the official aircraft transfer technical order. All MAJCOMs flying KC-135s concurred with this reconceptualized maintenance practice and have incorporated the standardized checklist into their aircraft transfer process. A true MAF-wide AFSO21 success!


Standardizing The KC-135 Aircraft Transfer Process

Aircraft Quick Turn Process: Increasing Velocity in the Mobility Environment

With today's unprecedented aircraft flying tempo, the 6 MXG needed a way to increase our aircraft availability to match the 6 Air Mobility Wing's (AMW) increased flying mission. We charged ourselves to review our aircraft quick turn process in an effort to afford the 6 MXG a greater opportunity to utilize the aircraft quick turn, in lieu of preflighting another aircraft or turning down a mission. This process needed to have at least a 90 percent predictability factor for success.

The wing formed a cross-functional team made up of experts in operations, maintenance, and support across the 6 AMW to review the established quick turn process. The wing was using 4 hours and 15 minutes as the scheduling standard for the current state. The group addressed every facet of the process including the aircrew's 30-minute call out procedures, tire roll over checks, aircraft taxi times, and aircraft parking locations. The team analyzed the operation and standardized the way we schedule our quick turn missions by adding notes concerning each quick turn in each affected line of the flying schedule. We also added reminders to the aircrew of the quick turn process during the aircrew 30-minute call out report. In addition, the group agreed to assign specific aircraft quick turn parking locations (to facilitate refueling if necessary) and postponed the aircraft *bird bath* until the last flight of the day. The bird bath is a unique aircraft clear water rinse used in highly corrosive environments to limit salt water corrosion. Finally the group agreed to eliminate the tire roll over check. The proposal to eliminate the tire roll over check required HQ AMC approval, and not only was it granted for MacDill, but it was implemented throughout the entire Air Force.

After a week of review and refinement, the team eliminated wasted actions that shaved 30 minutes off every quick turn at MacDill. Some may say, "It's only 30 minutes," but when you add those 30 minutes saved from every quick turn over the course of the year, the minutes add up to days. Though saving 30 minutes is nice, the true measure of how successful we were in our

charge comes when one looks at the flying schedule. A year ago, we may have had one quick turn scheduled in a week. Now the norm is for the wing to see three to four quick turns in a week. By allowing the 6 MXG to increase its quick turn opportunities, we have freed up three to four more aircraft a week to fly additional missions. We've also added predictability into our flying schedule by measuring ourselves against a 90 percent predictability factor. This has proven to be the benchmark in that 100 percent of our quick turns now take 3 hours and 45 minutes to execute—10 percent above our self-imposed scorecard.

Fuel Cell Wing/Confined Space Trainer: Improving Fuel Cell and Confined Space Training

The Fuel Cell Wing/Confined Space Trainer was recognized as a blue ribbon AFSO21 base-level initiative, and adopted by Air Education and Training Command as a *best practice*. In previous years, confined space training was accomplished on KC-135 aircraft that were not mission capable for maintenance. Once repaired, the aircraft was kept down to perform proficiency and skill-level upgrade training.

The development of the Fuel Cell Wing/Confined Space Trainer enables the 6 MXG to directly impact the AMC Commander's Annual Enterprise Improvement Priority vision to "reduce the cost to operate all functions of AMC by 10 percent ... and improve productivity of Airmen by 20 percent."

Additionally, the trainer facilitates confined space training for emergency rescue and fuel cell familiarization training, without requiring aircraft downtime. It is also used for familiarization training for machinists, sheet metal and metal technology personnel, and other specialists. We've recently included Airmen requiring nondestructive inspection certification to our user list, as we continue to maximize the number of Air Force specialty codes that are capable of utilizing this device.

This event was a joint effort between Grand Forks and MacDill AFBs. The team engineered this stand-alone device that simulates the exact dimensions of an actual KC-135 aircraft. The team coordinated with the Aerospace Maintenance and Regeneration Group, Davis-Monthan Air Force Base, AZ to obtain the left and right wing sections from a decommissioned donor aircraft, and transported the wing sections to MacDill and Grand Forks.

The 6 MXS fuel systems supervision coordinated with the fabrication flight to convert the wings into a brand new maintenance training device (MTD). The fire department began construction by cutting the wing sections into specified dimensions, and used the remaining structure for practice response to aircraft incidents and accident simulations.

Personnel assigned to the 6 MXS fastened the 13.6 foot by 2.6 foot wing section onto a 10 foot high steel stand which cost only $3,000 to construct. This eliminated the requirement for a dedicated aircraft for training purposes, and realized a $16,439 savings annually based on the KC-135's hourly operating cost. This initiative projected a savings of 5 days annually in aircraft downtime, which was significant to our operating tempo. The fuel cell work center now utilizes the MTD for 28 percent of career field education and training plan (CFETP) task certification training. Other work centers can also utilize the MTD in their area because the trainer is a mobile towable platform.

The second phase of this concept is currently in work. MacDill acquired an aft body cell cavity, which, when modification is completed, will allow bladder cell removal and replacement training. This capability adds an additional 30 percent of the CFETP tasks for bladder cell replacement training, which raises the overall CFETP task certifications performed on the MTD to a whopping 59 percent without the use of an aircraft. Other benefits include training certification for five support sections, zero training delays and overdues at home station, and increased proficiency during air and space expeditionary force cycles and deployments.

Improving the KC-135 Periodic Inspection Process

From 7 January through 25 January 2008, the 6 MXG hosted a 319 MXG led, MAF-wide AFSO21 event to standardize the #2 KC-135 Periodic Inspection (PE) across the Air Force. PEs are extensive 2-week inspections which evaluate the integrity of all structural components. It is the only time between major depot overhauls when maintainers perform in-depth inspections of an entire KC-135 aircraft. The look phase alone typically takes an average of 589 man-hours from start to finish. This does not include maintenance *fixes* that are required during the latter part of the PE.

The 6 MXG and 319 MXG partnered with 31 active duty, Air National Guard (ANG), and Air Force Reserve Command (AFRC) representatives from 14

Periodic Inspection #2 for the KC-135 Stratotanker

bases worldwide. The focus of this project was to combat the *consistently inconsistent* practices of the KC-135 #2 PE by establishing a standardized work flow based on the work card requirements. The team of experts observed a #2 PE on a MacDill jet for 1 week and spent 2 additional weeks creating a logical *future state*.

The team discovered immediately that the PE process varied across the represented bases. The process varied from 7 to 33 personnel and the numbers of flow days varied from 8 to 21 days to accomplish the same deck of work cards. This caused wide fluctuations with scheduling aircraft maintenance and achieving maximum aircraft availability. Variances by participating base are outlined in Table 1.

The PE team highlighted that manning was nonstandard across the KC-135 community. This was one of the contributing factors that made the #2 PE flow a nonstandard process.

The team also discovered that the support equipment required to accomplish this inspection varied among the bases as well. The team was able to produce a standardized *equipment required* chart and melded it into the equipment shortfall listing in Table 2.

The team studied equipment throughout the event and developed a critical equipment listing. This list of equipment is required to complete the flow of the #2 PE in the most efficient manner. The red blocks indicate equipment not available at a particular base.

The milestones achieved so far in this improvement process are:

- A standard work flow Gantt chart for all KC-135 bases
- An Air Force Knowledge Now Community of Practice Website specifically for PEs
- Forty-nine recommended technical order changes categorized as *just-do-its* and if approved will eliminate roughly 147 man-hours from the process

Other initiatives in this project could eliminate up to 48 more man-hours per #2 PE, which equates to 6,912 man-hours per year MAF wide. In addition to the MAF-wide PE event, the MacDill PE dock has taken advantage of open dock opportunities. The PE dock

Base	FLOW DAYS	WORK SHIFTS	SHIFT HOURS	CC PE MAN	CC FL MAN	TOTAL MAN CC	SP ASSIGNED	8 HOUR MAN DAYS	ACFT ASSIGN
Altus	8	2	8	12	6	18	15	144.0	24
Grand Forks	8	1	9	13	2	15	8	135.0	38
McConnell	8	3	9	10	2	12	8	108.0	39
Grissom	9	2	8	11	2	13	0	117.0	16
MacDill	9	1	10	11	1	12	5	135.0	16
Mildenhall	9	1	9	8	2	10	0	101.3	15
Fairchild	10	2	8	12	1	13	0	130.0	34
Robins	12	2	8	11	2	13	5	156.0	9
Scott	12	1	8	9	0	9	0	108.0	8
Kadena	14	2	9	9	2	11	0	173.3	16
Andrews	18	1	8	8	1	9	0	162.0	8
March	18	1	10	8	0	8	0	180.0	12
Tinker	18	1	9	7	0	7	4	141.8	12
Seymour	21	1	8	6	1	7	0	147.0	8

Table 1. Manpower Listing

	CRITICAL ITEMS TOTAL	WING STAND	CARGO DOOR STAND	AFT HATCH STAND	BOOM CABLE ACCESS ST.	OVER-WING STAND	RADOME STAND	MX TAIL PLATFORM	BOOM STAND	AREA PANEL RACKS	RUDDRVATOR RACK	FALL PROTECTION	PAPERLESS ISO	MAN LIFT (JLG/GENIE)	AIR HOSES	FORKLIFT	OVERHEAD HOIST	UKE/TOW BAR
Kadena	10	R	R	R	2	2	R	2	R		2	R	R	R	R		R	2
Andrews	6	R				2	R	2	R			R	R		r			2
Altus	5			R				2	R			R	R				R	2
Robins	5			R	2	2		2	R			R	R				R	2
Scott	4			R	2	2	R	2				R					R	
Grissom	3	R		R	2	2		2	R									2
MacDill	3		R	R	2	2				R						2		2
March	3			R				2				R	R					
McConnell	3				2	2		2	R			R					R	2
Mildenhall	3			R	2	2		2	R				R			2		2
Seymour J	3					2		2	R				R				R	2
Fairchild	2			R		2		2				R						
Tinker	2				2	2		2	R				R					
Grand Forks	0				2	2		2										
Eq Needed	52	3	2	9	9	12	3	13	9	1	1	8	8	1	2	2	6	9

Table 2. Equipment Listing

has taken on preflight and hourly postflight inspections, 900 hour inspections, and even volunteered to perform several #2 PE's for sister units to ensure personnel stay proficient and expedite experience gained in furthering the #2 PE continuous process journey.

The 126th Air Refueling Wing at Scott AFB hosted a PE work card validation just this past June. The event again included a total force make up of active duty, ANG, and AFRC personnel to validate the #1 and #2 PE work cards. They also validated technical order changes to include 23 approved changes from the January 2008 MacDill event.

The routine maintenance of a 50-year-old airframe becomes increasingly demanding as the aircraft fleet continues to age. The complexity is exacerbated by a myriad of issues including technical order changes, parts availability, and aircraft component wear that cannot be predicted from jet-to-jet or inspection-to-inspection. As an eventual outcome, the work cards will be reorganized into the new work flow and a standardized electronic work package will be implemented for all units Air Force wide.

AFSO21 Savings Initiative

In November 2007, the 6 MXS Metals Technology Section reevaluated its manufacturing processes with the intent to optimize base-level fabrication capabilities. The section proposed a new cutting-edge machine that could potentially enhance section productivity and reduce material waste. This machine is the OMAX Water Cutting Jet. This $220,000 piece of equipment removes material through erosion by introducing a concentrated high-pressure water stream along with fine sand particles. There are no blades or drill bits, just water which can cut virtually any two-dimensional shape from a sheet of steel up to 8 inches thick.

The major benefits realized from this technology include scrap material savings of $26,000 and programming setup times of 160 hours per year. The OMAX has the unique capability to cut closely nested shapes from one piece of metal which reduces scrap material by approximately 40 percent. Additionally, programming and setup time is reduced by as much as 80 percent. This is also an environmentally friendly process since it operates on a closed loop system, which doesn't introduce any new contaminates into the environment.

According to an extensive cost analysis, the 6 MXG will save up to $36,000 annually once this machine is put into place. With the monetary savings alone, the machine will pay for itself in less than 6 years. This initiative was proposed to HQ AMC in January 2008, and was identified as 1 of 14 initiatives from the

OMAX Water Jet Cutting Machine

command to have Air Force-wide applicability. The section secured funding from HQ AMC in August 2008 and hopes to have initial operating capability by 30 Septemer 2008.

Global Local Manufacturing *Factory*

Sharing Base-Level Factory Capabilities to Meet Department of Defense Demands

Because of our expeditionary nature and aging military airframes, local manufacture (base level) of aircraft parts is becoming a growing concern. The 6 MXS Fabrication Flight proposed this initiative to increase the agility of our manufacturing capability by rapidly responding to machinery and manpower availability worldwide while providing seamless support to expeditionary units. The proposed Global Local Manufacturing Factory Initiative (GLMFI) allows the *sharing* of base-level local manufacturing capabilities to meet demands across the Air Force and ultimately the Department of Defense.

The current local manufacture process focuses on satisfying a base-level demand with that particular base-level manufacturing capability. If parts cannot be made at the base-level because of broken machinery, limited manning, or lack of materiel, the demand is outsourced to the supply system, vendor, or depot. Once outsourced, vendors can charge an extensive programming and machine setup cost because of the urgency of the need and minimal quantity ordered. As a result, Air Force dollars are spent unnecessarily on minor components. Also, since deployed environments have limited machinery, most of the local manufactured items are outsourced.

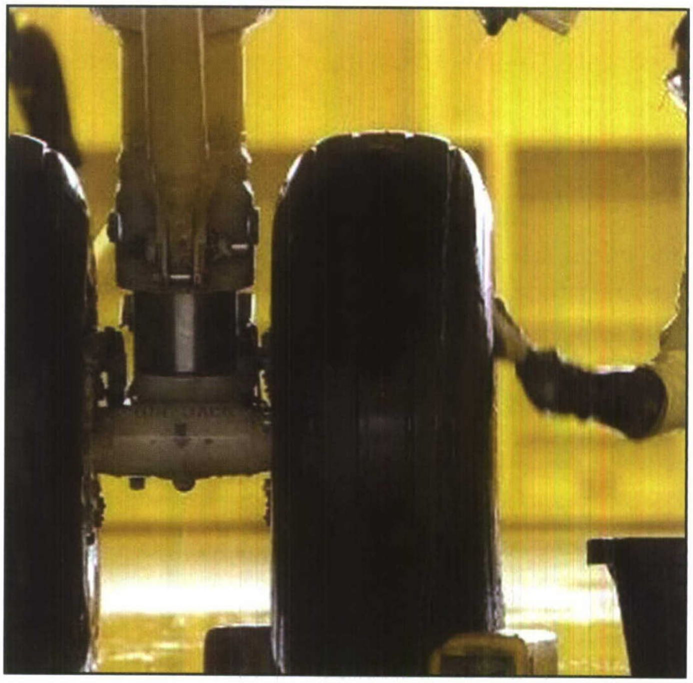
Current technology allows technicians to translate a computer program into a precision cut part. Most of the time and effort, however, is involved in writing the actual program. A recently developed Metals Technology Community of Practice Website is now serving as a database to allow users to store validated programming code. Once the code is written, anyone connected to the database can access that code from anywhere in the world and quickly translate that program into the part needed assuming the proper machinery is available.

The bottom line is the resources are available, but there simply isn't a network in place to allow bases to reach out to other military installations and share manufacturing capability. As an Air Force-wide initiative, creating a process to centrally order local manufactured items from any and all fabrication activities will prove effective on an enterprise level.

The implementation of this concept is just getting underway in the late summer of 2008. The 6 MXG, in conjunction with HQ AMC/A4M, is gathering data on local manufacturing workloads across the command to scope the problem. Once scoped and defined, an action plan will be developed to chart the future direction of the initiative. An eventual outcome could be the development of a command and control network, set up to provide a common operating picture with total asset manufacturing capability. It could drive the assignment of requirements to a specific shop. This idea, if turned into a capability, would allow locally manufactured parts to be managed through the Global Logistics Support Center (GLSC) much as the GLSC manages aircraft parts today.

Evaluating the Scope of Human Factors

Every 20 to 30 days each KC-135 must be hand washed by Airmen from the group. This process takes anywhere from 12 to 20 hours, and takes valuable technicians away from sortie production. The aircraft wash improvement process was a complete evaluation of an entire aircraft wash, which entails three phases: preparation, wash, and lubrication (lube) tasks. Key items were evaluated to include equipment, tasks, work environment, and training. The initial evaluation resulted in several just-do-it items. Hoses and reels needed replacement because of rust, wear, and tear. Also, scrubbing pads proved to be flimsy and



Aircraft Wash Process

ineffective. New, more effective pads were found and purchased.

On 20 April 2008, the evaluation team completed a *spaghetti chart* measuring the work of six wash team members. It was evident from this exercise that standard work was not accomplished throughout the three phases of the wash. This drove the evaluation team to create a wash tracking sheet to document and track scheduled versus actual completion times for each wash phase.

During the preparation phase evaluation, the team noticed that documentation and warning tags consumed on average 2.5 hours to complete. This means it took 1 person 2.5 hours alone just to complete the forms documentation and preparation of 25 warning tags. As a result, the team implemented laminated warning tags to streamline the documentation process. This saves 132 man-hours per year.

Finally the maintenance training flight also looked at the current state and suggested developing a training plan for future aircraft wash team members. The training will help cut out wasted effort.

Finally, the team is designing a wash workspace to create a *visual workplace*. Each piece of equipment will have a place in the hangar thus creating a more efficient work flow for wash team members.

Conclusion

MacDill, like many other bases, has identified better ways of utilizing manpower, equipment, and facilities by embracing the spirit of continuous reconceptualization of standard maintenance practices. We've effectively increased velocity and precision to accomplish our home station missions and ensured uninterrupted Global War on Terror support.

The group remains focused on AFSO21 for several reasons. First, it is a way for Airmen at all levels to rethink and engage the day-to-day waste inherent in all our processes and make continuous improvements. It is critically important to obtain buy in at all levels to ensure this will not become a passing fad. Next, Airmen recognize that leadership is serious about implementing the changes they suggest. Third and most important, leadership is given a tool to reduce workload on their troops. We've cut 2.5 work days off the #2 PE and reduced the duty day from 12-hour shifts to 10 hours. Our goal is to slash another 2 days and an additional 2 more duty hours per day per troop to get our folks *back* to a normal duty day and still roll out a quality product.

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***Master Sergeant Laron Dass**, the Aircraft Fuels Systems Maintenance Shop NCOIC for the 319th Maintenance Squadron and **Technical Sergeant Dale Bangert**, an aero repair craftsman for the 319th Maintenance Squadron, Grand Forks AFB, ND also contributed greatly to this article.*

He who will not apply new remedies must expect new evils; for time is the greatest innovator.

—Viscount Francis Bacon

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Air Force Smart Operations **in action**

The Problem Is Big, Time Is Short, and Visibility Is Enormous

Using AFSO21

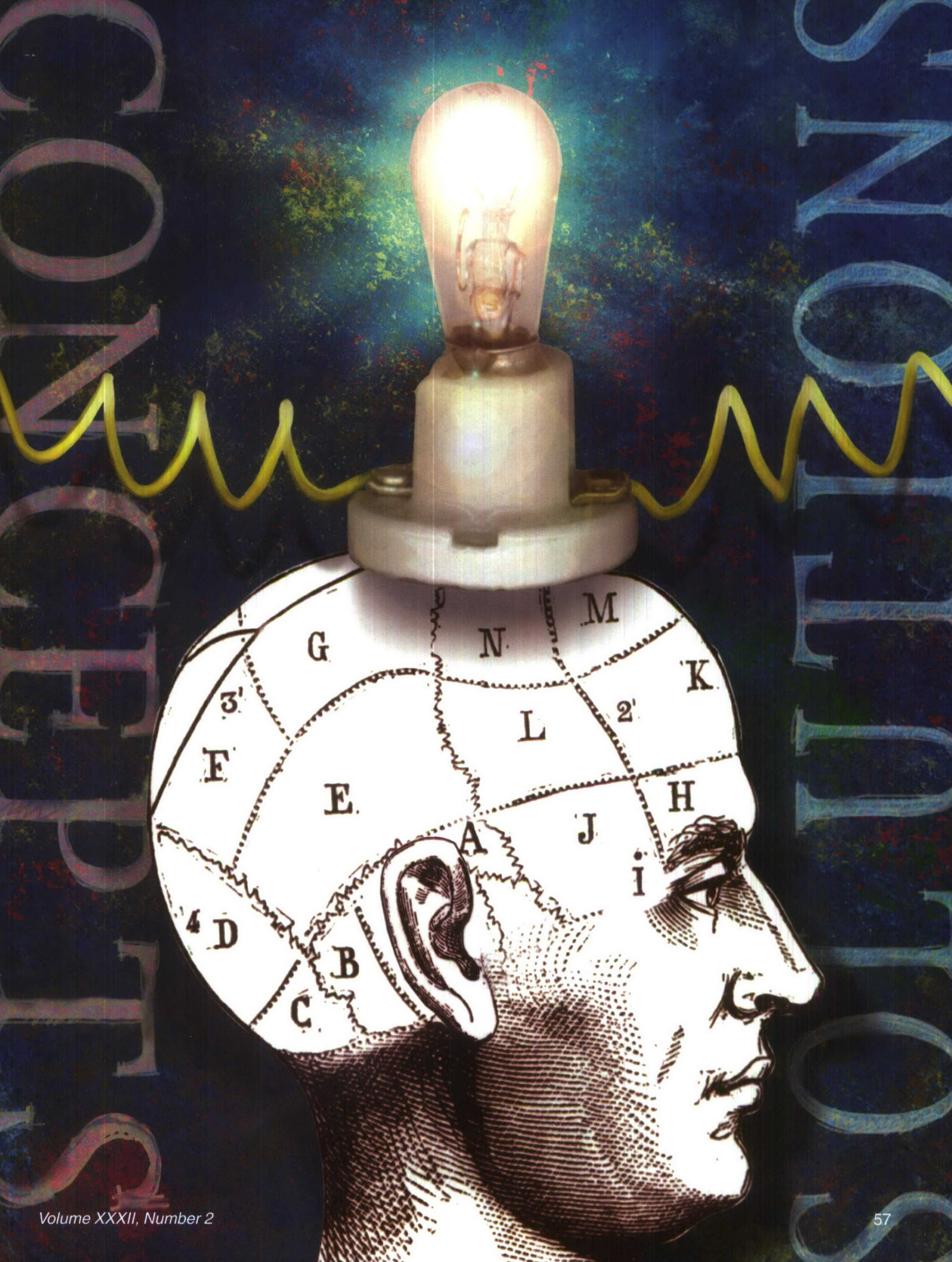
The foundation of the Comprehensive Assessment of Nuclear Sustainment (CANS) analysis was the aggressive use of Air Force Smart Operations for the 21st Century (AFSO21) tools to attack root causes. Though the effort was time constrained and many of the processes were modified to streamline the application, this did not detract from the effort, and actually enhanced the team's ability to use those portions of AFSO21 that made sense. Overall, the CANS effort highlights the power, flexibility, applicability, and simplicity of the AFSO21 toolkit and is a resounding success story.

Major Jennifer G. Walston, PhD, USAF

Introduction

When initially assigned to the Air Force CANS project, I wondered what role analysis would play in the effort. Typically, analysts are brought into projects after all the data has been collected and it is time to *analyze*. Most often, this is much too late for the analytic effort to have the optimum impact on the problem and its solutions. However, in this case, the CANS chairman brought me on board at the very beginning. This was a chance to shape the effort and to ensure that a methodical and repeatable analytic process was both followed and documented.

Given this phenomenal opportunity and the fact that I am an operations research analyst by trade, not an AFSO21 expert, why did I choose to use the tools of AFSO21? The simple answer is that it just made sense. When researching applicable industry methods for root cause analysis and risk analysis, the methods that I found most used by industry were available in the *AFSO21 Playbook*. Additionally, because the AFSO21 process is tailorable, we were able to use an industry accepted process and tools while still meeting a very short schedule. The remainder of this article reviews the methodology used in the CANS project.


CONCEPTS
SOLUTIONS

CANS Methodology

The focus of the CANS methodology was to not only investigate nuclear sustainment and develop solutions, but also to ensure a clear linkage would exist amongst the prioritized findings, root causes, and actionable solutions for implementation.

A team of subject matter experts (SME) was selected, divided into seven subteams, and subsequently consolidated into five working teams as follows:

- Organizational structure and lines of authority and responsibility
- Logistics and supply chain management
- Maintenance and storage
- Training and standardization
- Previous report review and research

In order to ensure that the CANS study produced solutions that addressed the root causes of the problem instead of only treating the symptoms, the team followed a methodical, industry and Air Force accepted, appropriately modified, 5-step problem solving approach called Define, Measure, Analyze, Improve, and Control (DMAIC)[11] which worked as a framework, encapsulating the overall solution methodology (see Figure 1). (Please note that at the time of this study, the Air Force had not yet fully adopted the Toyota 8-step problem solving model as the preferred model for AFSO21. For more information, see the AFSO21 Website.)

Define

The first step of the DMAIC model is to define the problem and develop an improvement project plan.

In this stage, the CANS team built subteam-level charters, defined the scope, and established milestones and roles. Additionally, based on the defined scope, the team developed a comprehensive questionnaire for the team to use during all site visits.

The overall problem was defined and scoped. From the definition, using affinity diagramming, cause and effect diagramming, and brainstorming,[3,4,5,10,11,12] the team determined and stratified key mission elements, or focus areas, contributing to the overall problem. These key mission elements are noted as follows:

- **Training.** Activities addressing the level of competence to execute the required job. They include formal training, education, on-the-job training, certifications, and experience.
- **Policy.** Activities that define how the Air Force does business. They should be clear, concise, standard, and relevant.
- **Culture.** Intangibles such as trust, support, accountability, internal and external environment, spirit, politics, pride, personal commitment, perceptions, and tribe mentality.
- **Resources.** People, equipment, systems, facilities, funding, and time.
- **Oversight and Control.** Activities that provide feedback on Air Force processes. They include performance measurements and metrics, inspections, closed loop feedback processes, and corrective actions.

Also during this step, the research subteam collected and reviewed over 2,000 documents related to the Air Force nuclear enterprise. From this group of documents, the research team identified 67 key documents and scrutinized previous findings as they related to the key mission areas. It is important to note that the other subteam members were not given access to the previous documents so that the data collection in the site visits would not be biased.

Measure

The second step of the DMAIC model is to measure the existing process and identify the process capability requirement.

The teams collected data through a variety of methods during the measurement step. These methods include the following:

- Site visits consisting of 23 members of the team visiting 31 sites with nuclear capability or related functions

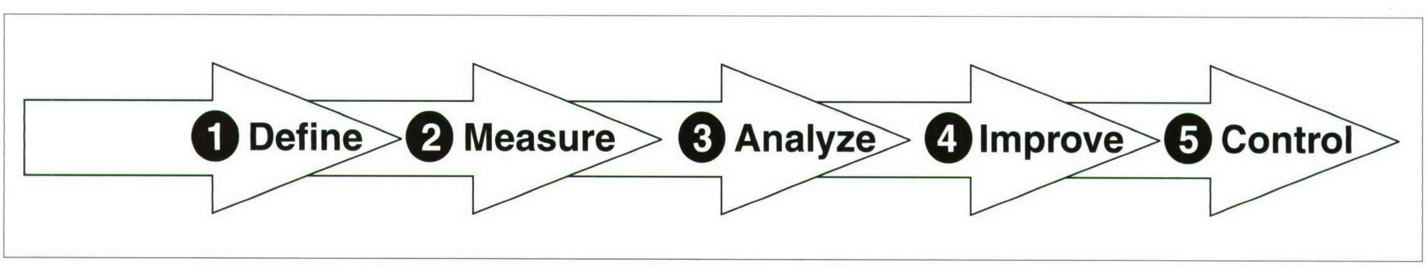


Figure 1. The DMAIC 5-Step Problem Solving Approach[5]

- Personal interviews during site visits, and followup interviews as needed with SMEs
- Research included staff studies, reports, policy, audits, and other sources
- A rapid improvement event addressing the engineering technical support process

Analyze

The process is analyzed to determine its capability. Data is analyzed to identify opportunities for improvement and to develop plans for improving the process. The steps in this phase include root cause analysis, solution development, risk analysis and mitigation, and determining the path forward.

Root Cause Analysis

Root cause analysis was conducted using proven methods, accepted by both industry and the Air Force. Specific methods used included flow diagramming (value stream or process), affinity diagramming, brainstorming, cause and effect diagramming, and the Five Whys. [3, 4, 5, 10,11,12] Brief descriptions of these methods follow.

- Flow Diagramming (Value Stream or Process Mapping). Value stream mapping (VSM) is a tool to visualize an entire process, such as the flow of material and information as a product or service makes its way through the value stream. It is a good method for displaying relationships between material and information, making waste and its sources visible, setting a common language and basis for discussion, and getting the *big picture*. Value stream mapping differs from process mapping in that it is broader in scope, tends to be at a higher level, and is typically used to identify where future focus should occur. The process map shows a process in more detail than a VSM. Such information is useful in analyzing all aspects of a specific process. VSM was used by the engineering team to map out the technical order 00-25-107 maintenance assistance engineering process. Process mapping was used by the engineering team to map out the information flow of the time change technical order process. The CANS team did not perform a full VSM on the entire Air Force nuclear sustainment enterprise due to time constraints. However, the team did use the tool to visualize the highest-level processes of the entire enterprise in order to scope the problem and to view the entire enterprise as one overall process. This was helpful as it highlighted the *seams* to organizations outside of the Air Force and was especially useful in integrating process solutions to non-Air Force processes.
- **Affinity Diagramming.** Affinity diagramming, sometimes called the JK Method for its creator Jiro Kawakito, is useful for organizing and presenting large amounts of data (ideas, issues, solutions, problems) into logical categories based on user perceived relationships and conceptual frameworks. When paired with brainstorming, affinity diagrams can help organize data and ideas, group like items, sort a large number of brainstorming ideas quickly, build consensus, avoid long discussions, stop people from dominating discussions, stimulate independent thoughts, and enable a greater variety of ideas. The CANS team used affinity diagramming when determining the five key mission areas.
- **Brainstorming.** Brainstorming is a problem solving technique in which team members attempt a deductive methodology for identifying possible causes of any problem via free-form, fast-paced idea generation. Brainstorming was popularized by Alex Osborn (advertising executive) in the 1930s, and can be an effective means to develop many ideas in a short amount of time. Brainstorming was used throughout the CANS study.
- **Cause-Effect Diagramming (Fishbone Diagramming).** Cause-effect diagramming, also called fishbone or Ishikawa diagramming, was created by Kaoru Ishikawa in the 1960s as part of the quality movement at Kawasaki Shipyards. It is a visual tool used to logically organize possible causes for a specific problem or effect by graphically displaying them in increasing detail. Additionally, it helps to identify root causes and ensures common understanding of the causes. In this method, a problem statement is written in a box on the right side of the diagram and then possible causes are determined (usually via brainstorming) as categories branching off the problem statement. Benefits include conciseness, adding structure to brainstorming, easily trained and understood, works well in team environment, and the ability to determine and analyze countermeasures. This method was used in determining the five key mission areas and during root cause analysis.
- **The Five Whys.** For root cause analysis, the team used the Five Whys, a well accepted method, first developed by Sakichi Toyoda of Toyota, described by Taiichi Ohno as "... the basis of Toyota's scientific approach," and is now widely used across industry and within AFSO21. The Five Whys

typically refers to the practice of asking, five times, why the failure has occurred in order to get to the root cause or causes of the problem. There can be more than one cause to a problem as well. In an organizational context, generally root cause analysis is carried out by a team of persons related to the problem. No special technique is required.

Using these tools, the hundreds of tactical findings discovered during data collection were analyzed to determine common trends or higher-level issues, which the team chose to call strategic level findings. These findings were then analyzed to determine the root causes. Finally, solutions were developed and then further scrutinized via a *murder board* process to ensure they truly solved the root causes instead of merely symptoms of the real problem.

Risk Analysis

Risk analysis[2,14] and mitigation was performed on each solution using a modified version of the Develop and Sustain Warfighting Systems (D&SWS) Core Process Working Group[13] Active Risk Management (ARM) Process model. Because of the high visibility and importance associated with the correction of the enterprise, the risks of not implementing the solutions were assumed to be known and sufficiently high such that all solutions would be implemented. Thus, the risk analysis in this study focused on the risks associated with implementing the solutions.

These risks were identified and analyzed as follows. The teams identified potential risks to solutions via brainstorming with SMEs by indentifying and explicitly defining potential unintended consequences which might occur when the solutions are implemented. These consequences were then scored by the SMEs, via a Delphi voting method, using life cycle risk management likelihood and severity ratings as defined in the D&SWS ARM Process model and shown in Tables 1 and 2. (Note that the CANS team focused on performance impact as the most critical characteristic. Each proposed solution was reviewed on the basis of consequence, vice cost or time to implement.)

Notional risk analysis output is shown in Figure 2, where the green squares identify a safe area where there is little likelihood of a risk occurring and low impact to the system if it does. Similarly, the yellow and red squares identify medium and high risk areas, respectively. The line is calculated by measuring the full range of the yellow area (medium impact) and determining the 98 percentile point. The team determined that the +98 percentile data points (within the medium area), could have very easily been scored within the red area (high impact) relative to the error margins within the scoring process and should be treated as high risk. Thus, solutions with risks above and to the right of this line required additional review by the teams to determine risk mitigation strategies.

1	Not Likely	1% - 20%
2	Low Likelihood	21% - 40%
3	Likely	41% - 60%
4	Highly Likely	61% - 80%
5	Near Certainty	81% - 99%

Table 1. Consequence Likelihood Ratings[13]

Prioritization via Multi-Objective Optimization

To determine a prioritized order, the strategic level findings were scored on their impact, if solved, on the five key mission areas. The result was then modeled as a multi-objective optimization problem in which five key mission areas represent the competing objectives and the prioritized order of the strategic findings represents the decision variable. In this type of problem, there often exists no single criterion for choosing the best solution. In fact, even the notion of *best* can be unclear when multiple objectives are present; and in many cases, it can be shown that improvement to one objective actually degrades the performance of another.[1]

The multi-objective optimization problem,

$$min\ F(x)$$

subject to

$$x \in \Omega = \{0,1)^n : g_i(x) < 0,\ \ i = 1,2,..., M\}$$

where $F{:}\{0,1\}" \longrightarrow R^J$, *is that of finding a solution* $x^n \in \Omega$ that optimizes the set of objectives $F = (F_1, F_2, ..., F_J)$ *in the sense that no other point* $y \in \Omega$ yields a better function value in all the objectives.[15] (Note the precise mathematical definition of x^n *can be found in Ehrgott*[8]) The point x is said to be *non-dominated*, *efficient*, or *optimal in the Pareto sense*.[9] The (typically infinite) set of all such points is referred to as the *Pareto optimal set* or simply the *Pareto set*. The image of the Pareto set is referred to as the *Pareto Frontier* or *Pareto Front*. If the Pareto set (or corresponding Pareto front) results from a solution algorithm and is not exact, it is referred to as the *approximate* (or *experimental*) *Pareto set* or *approximate* (or *experimental*) *Pareto front*, respectively.

Once defined, a multi-objective optimization problem can be solved via many methods. The particular method selected can depend on many factors including, but not limited to, the complexity of the problem, the time allowed for problem solution, the availability and quality of information, and the preferences of the decisionmaker. In this case, an *a priori* scalar method called weighted-sum-of-the-objective-functions (WSOTOF) was selected. As the name implies, this method combines the various objectives via a convex combination (a weighted sum). Though it is among the simplest of the multi-objective methods, it is guaranteed to produce an efficient solution (see Lemma 3.3.11 in Walston[19]). It should be noted that this method is not guaranteed to find all possible solutions, particularly if the corresponding Pareto front is non-convex;[6,7,16,17] however, in this particular case, the benefits of simplicity and speed far outweigh potential risks associated with examining only a portion of the Pareto front.

	DoD Guide	Proposed Air Force Definition
1	Minimal or no consequence to technical performance	Minimal consequence to technical performance but no overall impact to the program success. A successful outcome is not dependent on this issue; the technical performance goals will still be met.
2	Minor reduction in technical performance or supportability, can be tolerated with little or no impact on program	Minor reduction in technical performance or supportability, can be tolerated with little impact on program success. Technical performance will be below the goal, but within acceptable limits.
3	Moderate reduction in technical performance or supportability with limited impact on program objectives.	Moderate shortfall in technical performance or supportability with limited impact on program success. Technical performance will be below the goal, but approaching unacceptable limits.
4	Significant degradation in technical performance or major shortfall in supportability; may jeopardize program success.	Significant degradation in technical performance or major shortfall in supportability with a moderate impact on program success. Technical performance is unacceptably below the goal.
5	Severe degradation in technical performance; cannot meet KPP or key technical/supportability threshold; will jeopardize program success	Severe degradation in technical/supportability threshold performance; will jeopardize program success.

Table 2. Risks

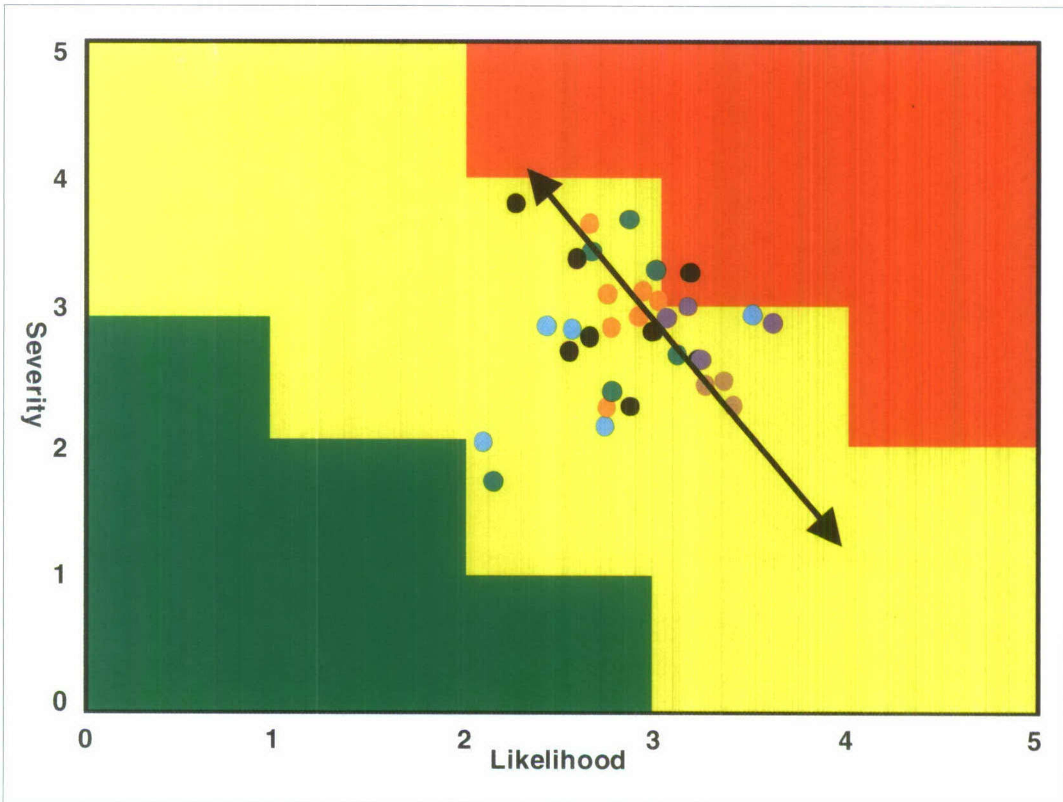


Figure 2. Notional Risk Analysis Output

To combine the objectives, the WSOTOF method requires a predetermined set of weights. In many cases, this can be problematic[18] as it is dependent on subjective judgment of the decisionmaker which may not be available or fixed across the duration of the study. Thus, this step is of particular importance. Additionally, in this particular problem, the determination of weights is even more complex as there are multiple decisionmakers to be considered.

To ensure that multiple decisionmaker preferences are included and considered in the solution, the following method was used. First, a group of senior Air Force leaders was identified as stakeholders for the nuclear sustainment enterprise and defined as the decisionmakers for the multi-objective problem. After each stakeholder provided a set of weights, the problem was solved as follows:

- A simple average of the weights provided by the stakeholders was used as the weights for the problem. However, there was considerable variance in the weighting schemes provided by the stakeholders (see Figure 3 and Table 3) indicating that further investigation was necessary. The distribution of the weights was tested for normality using normal p-p plots and the Kolmogorov-Smirnov (K-S) goodness test for normality. The plots and the K-S test indicate failing to reject the null hypothesis that the weights are normally distributed. Though in this case, parametric statistics would then be applicable, the use of a simple mean may not be adequate because of the high degree of variance.
- The weights were further analyzed as follows. A sensitivity analysis was conducted to determine the impact of the weighting scheme on the overall prioritized solution. It was found that the top priority issues in the prioritization solution were relatively impervious to the weighting scheme. A prioritized list of findings was determined for each decisionmaker's preference of weights and was then examined against the others. In this case, it was also found that the top priority issues did not vary much over the various weighting schemes. The average of the ranks assigned from each weighting scheme was determined for each finding, and was used to assign its final rank.

Once the objectives have been combined, any applicable optimization method can be used to determine the prioritized list of findings. In this case, because no constraining information was identified, and impact to the overall problem statement was the sole criteria for selection, a simple greedy heuristic method was used. Simply stated, once the weights are determined, the *value* of solving each particular finding becomes clear, and the prioritized list follows directly.

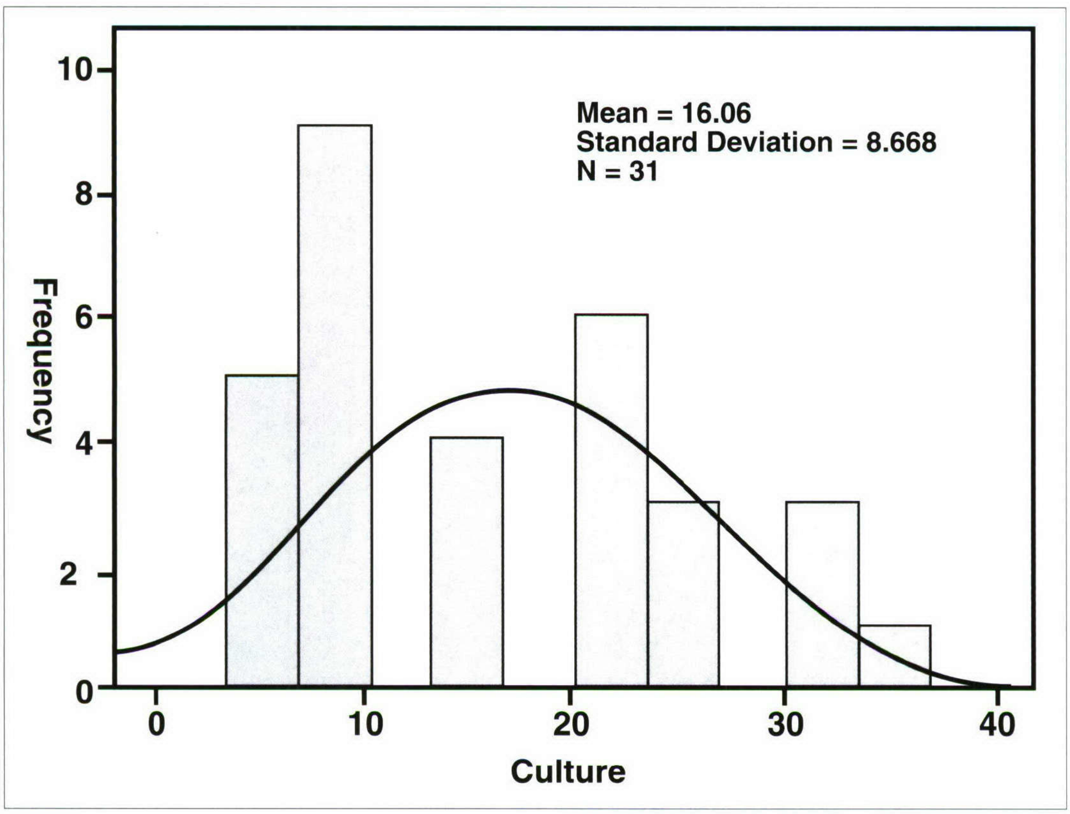


Figure 3. Histogram of Weights Assigned to Culture

	N	Minimum	Maximum	Mean	Standard Deviation	Variance
Training	31	5	40	22.16	7.267	52.806
Policy	31	10	50	21.77	8.995	80.914
Culture	31	5	35	16.06	8.668	75.129
Resources	31	5	40	22.52	8.282	68.591
Oversight/Control	31	5	30	17.48	5.591	31.258
Valid N (listwise)	31					

Table 3. Descriptive Statistics

Cost Analysis

The CANS cost team estimated costs for solutions that required funding. Cost analyst support upfront was critical to providing leadership with vital financial information. As solutions were identified, the cost team worked to define tasks, timelines, and associated costs. Identifying and linking costs with solutions allows leadership to make timely, informed decisions with known costs. In this case, costs of the CANS solutions totalled $25.6M for fiscal year 2008—the process worked and our leadership provided the funding to fix the problems because the methodology was solid.

Improve. During the Improve step, the plan that was developed in the Analyze phase is implemented. The results of the change are evaluated and conclusions are drawn as to its effectiveness. This can lead to documenting changes and updating new instructions and procedures.

The CANS chairman was given authority to immediately implement some solutions. There were six *just-do-it* solutions. The remaining results of this team's efforts were presented to senior leaders in a number of briefings at the major commands and Air Staff.

Control. Control plans were developed to ensure the process is institutionalized and continues to be measured and evaluated. This can include implementing process audit plans, data collection plans, and plans of action for out-of-control conditions, if they occur.

This study team worked concurrently with SAF/IG (Secretary of the Air Force, Inspector General's office) and AF/A9 (Studies and Analyses, Assessments, and Lessons Learned Directorate) to develop inspection and assessment criteria and plans to assess the status of the Air Force nuclear sustainment enterprise and measure the progress of addressing the CANS findings.

Conclusion

The foundation of the CANS analysis was the aggressive use of AFSO21 tools to attack root causes. Though the effort was time constrained and many of the processes were modified to streamline the application, this did not detract from the effort, and actually enhanced the team's ability to use those portions of AFSO21 that made sense. Overall, the CANS effort highlights the power, flexibility, applicability, and simplicity of the AFSO21 toolkit and is a resounding success story.

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Award-Winning Continuous Process Improvement

WR-ALC and AFSO21

In addition to having an official Air Force Smart Operations for the 21st Century (AFSO21) advisor, the Warner Robins Air Logistics Center also utilizes an AFSO21 Panel and Transformation Management Board. The AFSO21 Panel allows change managers from the wings and staff offices to meet to discuss issues relevant to AFSO21. Panel members share success stories, benchmarking ideas which might work across wing lines, and the latest information and guidance received from Headquarters Air Force Materiel Command and Air Force-level AFSO21 officials. The Transformation Management Board is comprised of wing and staff office leadership who meet to discuss issues relevant at the center level.

Lisa Mathews, USAF

Introduction

When the Secretary and Chief of Staff of the Air Force issued a joint memorandum to "Lean across the Air Force" on 7 November 2005, Warner Robins Air Logistics Center (WR-ALC) was prepared for the challenge. The center proceeded to do business much as it had before. In 1999 the center adapted a version of the Toyota Production System, which is also known as *Lean*, in the F-15 Avionics and F-15 Wing Shop. By 2005 Lean practices had progressed beyond maintenance activities and into the administrative arena.

On 11 July 2006, another joint memorandum was issued to introduce AFSO21. AFSO21 is the umbrella under which all continuous process improvement (CPI) initiatives fall, including Lean, Six Sigma, Theory of Constraints, and others.

One major factor in the successful pursuit of continuous process improvement initiatives at WR-ALC has been the commitment of senior leaders at the center. Beginning with Major General Richard Goddard, commander of the center when Lean was first introduced in 1999, to the current commander, Major General Polly A. Peyer, WR-ALC personnel have had the support of leaders to *think out of the box* to find ways to complete the work, while at the same time improving quality, on-time delivery, and to do so at the lowest cost.

Kudos and Awards

Even before November 2005, WR-ALC was being recognized for successes gained by using CPI initiatives. Earlier that year the center was the first Department of Defense (DoD) entity to receive gold level Shingo recognition for the C-5 programmed depot

78th Medical Group AFSO21 Efforts

Ensuring patients receive the best possible care in the most timely manner is a priority for the 78th Medical Group at Robins. The group's commander, Colonel Jim McClain, said the concept of process improvement is an important part of the reason the group can efficiently and effectively accomplish their mission.

"In the medical business we, like any organization, face challenges with manpower, challenges with money, and we support a very diverse population," he said. "The medical business itself is a very complex process. Most patients don't see that process; they just see the point-of-contact with the physician, and they don't see all the other dynamics behind it."

McClain credits Air Force Smart Operations for the 21st Century (AFSO21) and Lean initiatives for the group's successes to date in eliminating waste in processes and he said the group strategically plans events each year to continue improving.

Major (Dr) Chrystal Henderson, chief of the medical staff, and Katty Adkins, manager for quality, patient safety, and performance improvement, are two champions of the implementation of AFSO21 initiatives, according to the colonel. He said the two have played important roles over the last couple of years with multiple AFSO21 events for improvements in areas such as access to care, optimizing annual health care assessments, medical evaluation board processes, appointment scheduling and standard work in healthcare operations.

"We've just recently completed our third AFSO21 look at our preventive health assessment, and our annual health assessment process," McClain said. "That's key to the AFSO21 concept—it's not just a one-time thing; you're always looking for ways to improve and make it better and better."

maintenance process. Shingo has been described as the *Nobel Prize* in manufacturing.

The C-5 programmed depot maintenance (PDM) line repeated the gold-level success in 2006 and the center also received two other Shingo awards. Both the F-15 PDM and F-15 Avionics programs were named bronze-level recipients. The following year (2007), the F-15 Wing Shop was a bronze-level recipient.

In 2007, the center's personnel directorate was awarded the Human Capital Management for Defense Award in the Most Innovative Recruitment and Retention Program category when the organization, through AFSO21 initiatives, was able to cut the fill rate from an historic average of 100-plus days down to the 78 to 80 day range. The award was presented by Worldwide Business Research, a non-DoD organization.

The center won the Franz Edelman Award for Achievement in Operations Research in 2006. Referred to as the *Super Bowl* of operations research, the award brings together the best examples of innovation from large and small, for-profit and nonprofit, corporate and governmental organizations around the world. The winning entry discussed how the center used a technique called Critical Chain Project Management (CCPM) to reduce the number of C-5 aircraft being repaired and overhauled in the depot from 13 to seven in just 8 months. Through CCPM, the time required to repair and overhaul the C-5 was reduced by 33 percent.

When accepting the award for the center, Ken Percell, the WR-ALC AFSO21 advisor and director of the engineering directorate, said,

> Warner Robins is extremely pleased to receive the Franz Edelman Award for our work

C-5 Programmed Depot Maintenance work is carried out at the Warner Robins Air Logistics Center. When this aircraft, the largest cargo jet in the US Air Force fleet, first arrived at the center it took longer than 300 days to complete the PDM. Through Air Force Smart Operations for the 21st Century initiatives, the PDM process is now averaging less than 170 days. Because of the continuous process improvement initiatives put in place by the C-5 PDM program, the center has received two gold Shingo awards—first in 2005 and again in 2006—as well as the Franz Edelman Award for Achievement in Operations Research in 2006.

Warner Robins Air Logistics Center performs the F-15 programmed depot maintenance. By using Lean methodologies and the tools in the Air Force Smart Operations for the 21st Century toolbox, the center has streamlined the process to return the F-15 Eagles back to the warfighter on time, on cost, and at improved quality. One of the AFSO21 events culminated in the development of the tail stands shown in this picture. These stands allow workers on either side of the tail to raise or lower their platform to better accommodate their body height. Mechanics also have their tools on hand and avoid constantly going up and down the steps to retrieve tools needed to perform each task. The F-15 PDM line, the F-15 avionics shop and the F-15 wing shop have all been bronze recipients of the Shingo Award.

on reducing flow days for the C-5 aircraft line. The results underscore the gains that a proper application of these tools can offer to the Air Force. This accomplishment should reinvigorate the use of operations research in the Air Force and across all branches of the military in general.

A Look at WR-ALC

WR-ALC is located at Robins Air Force Base, Georgia. The base is large—8,400 acres—with more than 20,500 personnel to include military, civilian, and contract employees. The base is home to the center as well as associate units which include Headquarters Air Force Reserve Command, 116th Air Control Wing, 5th Combat Communications Group, Defense Logistics Agency, and Global Logistics Support Center.

The Lean journey at the center began in the 402d Maintenance Wing. It has since been deployed into the 330th Aircraft Sustainment Wing, the 542d Combat Sustainment Wing, the 78th Air Base Wing, and supporting center staff offices.

Now the center is assisting its associate units as they begin their AFSO21 journey. Assisting others in learning how to use the tools and methodology of AFSO21 is not new to the transformation branch of the WR-ALC Directorate of Plans and Programs.

In addition to having an official AFSO21 advisor, WR-ALC also utilizes an AFSO21 Panel and Transformation Management Board. The AFSO21 Panel allows

An event on health care operations accomplished just that.

"The healthcare optimization event decreased the overall number of steps taken by clinic personnel during each patient's visit," said Henderson. "By decreasing the number of steps overall, the transit time for patients within the clinic during their visit was decreased 50 percent."

An Air Force Materiel Command-led effort is ongoing to apply AFSO21 to medical operations throughout the command, McClain said.

"AFMC is the Air Force medical service AFSO21 champion and Robins Air Force Base, specifically the 78th Med Group, has been identified as the champion for expeditionary health processes," the colonel said. "So anything health related to getting people out the door to support our military operations, we are the champion for AFMC for that process."

From a recent predeployment rapid improvement event (RIE), they estimate a 50 percent reduction of time a patient will need to spend in the medical group to ensure all of their healthcare needs are met prior to deployment.

The colonel said that, eventually, the gains realized by AFMC could be used throughout the entire Air Force.

The group not only works to improve processes for deploying military, they also look for ways to improve healthcare services to all patients which include military, retired military, and dependents.

The group has developed the one-stop shop method. For example, the PHA process previously included multiple visits to the clinic. Now, for most cases, patients are in and out in one visit, and the time for that visit has been reduced from several hours to, on average, less than 1. Patients now are seen in one room, and the healthcare providers come to the patient rather than the patient having to move throughout the clinic to different locations.

"The medical management event integrated the different areas involved

in the care for complicated patients under one umbrella, which has enhanced continuity of care for those patients and decreased the likelihood of parts of their care falling through the cracks," said Henderson.

She added that additional events, such as 6S (which stands for sort, straighten, shine, standardize, sustain, and safety) also take place during the year.

The group recently was the winner in the 78th Air Base Wing's 6S competition. Through the group's 6S event in their logistics area they accomplished a 698-percent increase in available floor space and realized a savings of $17,000 when they were able to cancel an order for additional shelves.

The group has a dedicated core team that annually plans 10 to 12 events. Adkins and Henderson are both members of this core team.

"Annually, we strategically plan events so that we have a game plan pertaining to what we want to focus on," McClain explained. "We generally try to focus on the things that will bring us the greatest value and the things that have the most importance to our patients."

78th Communication Group AFSO21 Efforts

When Warner Robins Air Logistics Center conducted an operation risk reduction (ORR) inspection, findings showed areas of concern which needed to be addressed. Through AFSO21 and Lean initiatives, courses of action were defined to correct these areas of concern.

Information technology might not be the first thing to come to mind when thinking ORR, but Carl Unholz, 78th Communications Group director, said his organization discovered a lot of things to think about.

"When you think ORR, you think of safety and such," he said. "You don't necessarily think of business software; but, in fact, we were one of the original buckets."

change managers from the wings and staff offices to meet to discuss issues relevant to AFSO21. Panel members share success stories, benchmarking ideas which might work across wing lines, and the latest information and guidance received from Headquarters Air Force Materiel Command and Air Force-level AFSO21 officials. The Transformation Management Board is comprised of wing and staff office leadership who meet to discuss issues relevant at the center level.

Both the board and the panel have charters and have been determined to be useful tools in sharing AFSO21 successes in order that other organizations may learn from individual groups' experiences and synergize capabilities.

Sharing Knowledge with Others, Spreading the Skills

Calvin Butts is now the civilian deputy director of the WR-ALC Directorate of Plans and Programs. In 2005 Butts was an active duty lieutenant colonel deployed for 4 months to support the war on terrorism in Iraq. Under his leadership military members from all branches of the military worked to set up a Joint Air Cargo Operations Team (JACOT). The JACOT was used to mitigate cargo losses by using airlift for transport versus convoys. He commanded a team of 29 Airmen as well as a company of Marines, soldiers, and sailors.

"You don't have a better incentive to Lean out and streamline your processes than when people are shooting mortars at you while you're working," Butts said. "If they would've hit an aircraft on the ground, it would've been a big victory for the terrorists.

"So we had to expeditiously work those aircraft and protect the crews—get them in and out as quickly and safely as we could," he said.

Butts put the same methodology in Lean that WR-ALC had been implementing to work in his deployed location. "We actually redesigned the cargo and passenger flow on ground time to one-sixth of the normal previous times," he said. "While the average C-130 takes in excess of 30 minutes to upload and download, the JACOT was able to get it done in less than 20 minutes. C-17s, which once took more than an hour, were fully uploaded and downloaded in less than 20 minutes."

"The aircrews loved us for that because they didn't want to hang around," Butts said. "We used a lot of the same steps we do in Lean events at the center. The more time the aircraft were on the ground, the more vulnerable they were to a stray rocket or mortar. So we worked hard to cut those times."

By the end of the deployment, Butts' group had worked 1,200 missions and moved more than 26,000 tons of cargo and 32,000 military passengers.

"Sixty-plus convoys were not necessary because of airlift. That's a good feeling to know the GIs don't have to risk it on those roads," he said. "It was good for the Marines as well as the Air Force and Army, because fewer convoys were getting shot up on the roads. It was especially good for my Air Force troops because it showed them one of many areas where we can have significant relevance to the war on terrorism."

WR-ALC, along with the other two air logistics centers, has led the

way in sharing AFSO21 knowledge to the other Air Force bases and organizations. Soon after the announcement that AFSO21 was going to become an Air Force-wide initiative, people from other Air Force bases began contacting the transformation branch at WR-ALC for information and assistance on how to implement AFSO21 at their locations.

AFSO21 professionals from the center took temporary duty assignments to some of these bases to help facilitate AFSO21 events and to train others on how to put AFSO21 to use in areas outside the air logistics center arena. Many Air Force military and civilians have come to WR-ALC for AFSO21 training and to tour areas where processes have improved significantly because of improvements gleaned through AFSO21 implementation.

But the sharing of skills and knowledge has not been limited to a US Air Force audience. Many people from other DoD branches as well as military personnel from other countries, such as the Royal Air Force from the United Kingdom and the Royal Australian Air Force, have found their way to WR-ALC to learn more about the steps taken to improve processes which have netted great results for the center.

A Sampling of Successes

WR-ALC has used a variety of tools to improve processes and eliminate waste, such as value stream mapping, standard work, 6S events (which stands for sort, straighten, shine, standardize, safety, and sustain) rapid-improvement events, root-cause analysis, strategic alignment and deployment, and many others. Some of the successes the center has experienced have had major

Then Lieutenant Colonel Calvin Butts, far left, stands with a group of military personnel from his consolidated Joint services team. Under his leadership, military members from all branches of the military worked to set up a Joint Air Cargo Operations Team. During his deployment in 2005, Butts commanded a team of 29 Airmen as well as a company of Marines, soldiers and sailors. Butts is currently the civilian Deputy Director, Plans and Programs Directorate, Warner Robins Air Logistics Center.

The group, which was the information technology (IT) directorate at the time of the inspection, had 35 findings of noncompliance issues across the center in regards to IT, IT systems, and infrastructure following the ORR.

"We discovered that a lot of the findings attributed to the *production-first* mentality," Unholz said. "It was OK to break the rules, as long as we were getting something done quicker; or so we thought."

The directorate, which had only recently stood up when a focused area risk reduction team was at Robins, used the findings and the ORR, to develop a roadmap for their business processes.

"We as a center were being very inefficient and ineffective about how we were doing IT. We had no centralized planning, which resulted in a high level of expenditures without much analysis about what we were spending it for," Unholz said. "We had a lot of projects, either command-wide, Air Force-wide, or even Department of Defense-wide; and yet we didn't send the right subject matter experts. So we ended up, in the end, getting a product that didn't meet our needs. That put us into an immediate condition where we needed changes made, and there was no good requirements process to handle those things," he added.

After a comprehensive analysis of the organization's processes, the directorate developed 61 courses of action. That was the highest number of any organization on base, including the wings, Unholz explained.

"I hope this demonstrates how seriously we took this," he said. "We wanted to dive into these issues and details and arrive at an effective way ahead."

The director, who describes himself as a Lean advocate, said that using the Lean principles helped the organization arrive at the smarter solutions in a shorter period of time.

"The result was a wonderful roadmap for us in how to move ahead

and change the way we were doing business," he said.

Starting with 61 tasks, IT currently has only one task still outstanding.

Results from the organization's work have been very good, Mr Unholz said. When the ORR was first begun, the organization was spending $112M on IT. Now, 2 years later, this amount has dropped to around $41M. The directorate has also saved base organizations man-hours by turning back 145 positions which, in the past, had to work IT issues as well as other duties.

"So we've overcome all service gaps and are providing efficient support with fewer dollars and less people," Unholz said. "We're getting much greater value for our investment because of the changes," he explained.

The customer has been involved in all aspects of the organization's change. IT zones and help desks have been established to deal with issues when someone has a computer problem they need fixed.

Liaisons and requirements managers are in place for the wings and staff offices. The liaisons work to fully understand customer needs and bring their concerns to the 78th Communications Group's attention.

"When we meet, even if the customer isn't there, we still have someone who knows their concerns and issues and can bring those to the table for them," Unholz said. "We have a customer perspective in everything through the liaisons and the way we're organized."

The director said the actions that came out of the ORR have helped the organization better deal with current budget and personnel cuts the Air Force is facing.

"We find, as long as we explain to the customer why we are doing something, they can accept and support what we have to do, whether it is because of security or cost reasons," Unholz said.

impacts (some have been more minor), but all improvements help the center stay the course of striving for perfection. While understanding true perfection is not really possible, AFSO21 helps the workforce to relentlessly eliminate waste to help support war-winning capabilities.

The tools of AFSO21 and Lean allowed the center to complete PDM on 23 C-5 aircraft in fiscal year 2003, something that had never been done before. Other accomplishments in the C-5 PDM area include cutting PDM flow days from more than 300 to less than 170, freeing up an entire dock in the hangar for other work, and taking on the torque deck work on the aircraft—work that had previously been done by contractors.

The F-15 Wing Shop Leaned out its processes and have managed to complete work on all F-15 wings on time, every time, since June 2003. The wings are worked through the cells in the shop in a neat, logical order.

Developing kitting processes, shadow boxes for tools and instruments, and implementing visual management for items frequently used in various shops has reaped benefits for all manufacturing and production areas of the 402d Maintenance Wing. Personnel are dedicated to restocking supplies, thus eliminating the need of technicians and mechanics to leave their work areas to travel (sometimes to another building), for parts and tools. This ensures that work continues uninterrupted.

Through streamlining portions of the end-to-end process of filling civilian positions, the personnel directorate (DP) at Robins has been able to reduce the time to complete the process from 160 to 120 days. While doing this, DP developed a new employee orientation through which all new employees receive initial training in various aspects of their jobs as well as the center, its mission, and AFSO21 basic awareness.

The list could go on and on; the above are just a few examples of how AFSO21 has had a positive impact at WR-ALC, and in turn, the greater Air Force enterprise. The center has maintained a high operations tempo, increased throughput and capacity, and worked on developing and sustaining a culture of continuous process improvement throughout the organization. With leadership support and innovative thinking we are motivating teams to new and better ways to effectively support the warfighter. Team Robins will continue the drive to be America's dominant air and space power sustainer. Included with this article are two short articles with more in-depth detail on specific areas at the center which have benefitted from continuous use of AFSO21 principles. The 78th Communications Group and the 78th Medical Group, through numerous Lean and AFSO21 events, have experienced unprecedented success in eliminating wasteful steps in their work to provide better support to the Air Force.

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Special Feature

It is impossible to discuss the total not mission capable maintenance rates and standards without including discussions of the mission capable and the total not mission capable supply rates and standards. These three rates are dependent upon one another.

logistics aircraft maintenance

Establishing C-5 TNMCM Standards

The featured article in this edition of the *Journal* is part three of a three-part series that examined total not mission capable maintenance (TNMCM) rates for the C-5 fleet. Part one can be found in *Air Force Journal of Logistics*, Volume XXXI, Number 4 and part two in Volume XXXII, Number 1.

Part one presented a new method for determining available maintenance capacity—net effective personnel (NEP). The NEP calculations were ultimately used in conjunction with historical demand to propose base-level maintenance capacity realignments resulting in projected improvements in the C-5 TNMCM rate.

In part two, the research demonstrated that home station logistics departure reliability is aligned with neither aircraft availability nor TNMCM. Maintainers at the wing level work to support operational effectiveness; however, higher levels of Air Force supervision appear more focused on improving strategic readiness. This disconnect in priorities was determined to be a root cause of the C-5 TNMCM rate being below Air Force standards.

Part three research demonstrates that the process for calculating and establishing Air Force-level TNMCM standards is not well known across the Air Force and not equally applied across the total force. Also, the process currently in use does not produce realistic, capability-based metrics to drive supportable operational decisions.

The authors conclude part three by recommending that a repeatable methodology be developed to compute the TNMCM standard so that it:

- Reflects day-to-day minimum operational requirements
- Adjusts to fully mobilized force capabilities and surge mobility requirements
- Accounts for historic capabilities and fleet resources

Establishing C-5 TNMCM Standards

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Introduction

This article details the process for calculating and establishing Air Force aircraft total not mission capable maintenance (TNMCM) standards. It is impossible to discuss the TNMCM rates and standards without including discussions of the mission capable (MC) and the total not mission capable supply (TNMCS) rates and standards. These three rates are dependent upon one another. Because the rates are percentages of total unit-possessed time, one rate cannot increase or decrease without impacting the other two. The Air Force standards applied to these metrics are interrelated as well. As discussed in this article, the TNMCM and TNMCS standards depend on the MC standard. Thus, the formulation of the MC standard is the foundation for the TNMCS and TNMCM standards.

Special Feature

The 2003 CORONA directed that Air Force-wide standards for MC, TNMCM, and TNMCS be established. While directed toward TNMCM, the research detailed in this article also revealed that the MC standard is the foundation for calculating the other two metric standards. As the process exists currently, the Air Force MC standards are based on requirements which are determined in one of three ways:

- The flying hour or flying schedule requirement
- Contract logistics support (CLS) contract
- Another requirement based on major command (MAJCOM) input determined by the designed operational capability (DOC) statement, readiness study, or any operational requirement the MAJCOM may use

In the case of the Air Force's C-5 Galaxy, Air Mobility Command (AMC) provides the active duty fleet MC standard to the Air Staff based on the *Mobility Requirements Study* (MRS). However, the standard is not actually calculated in the MRS, it is an assumption used in the MRS.

This is not the case for the separate Air Force Reserve Command (AFRC) and Air National Guard (ANG) fleet C-5 MC standards. Those two values are calculated at the Air Staff level. The AFRC MC standard is calculated from utilization rate, attrition, turn pattern, annual fly days, spares, aircraft held down for scheduled maintenance, and primary aerospace vehicles authorized. The ANG MC standard equation uses variables portraying daily operations and maintenance (O&M) flying hours, aircraft taskings per flying day over and

Article Highlights

There are numerous implications for the complex, seemingly disjointed standards methodology that are problematic for the Air Force at the strategic, operational, and tactical levels.

At the request of the Air Force Materiel Command Director of Logistics, AFLMA conducted an analysis in 2006-2007 of total not mission capable maintenance (TNMCM) performance with the C-5 Galaxy aircraft as the focus. The *C-5 TNMCM Study II* included five objectives. One of those objectives was to analyze the process for calculating and establishing TNMCM standards. This article details the analysis conducted in support of that particular study objective.

It is important to recognize that any discussion of TNMCM rates and standards must also include discussions of the mission capable (MC) and the total not mission capable supply (TNMCS) rates and standards. These three rates are dependent upon one another. Because the rates are percentages of total unit-possessed time, one rate cannot increase or decrease without impacting the other two. The Air Force standards applied to these metrics are interrelated as well. As the authors point out, the TNMCM and TNMCS standards depend on the MC standard. Thus, the formulation of the MC standard is the foundation for the TNMCS and TNMCM standards.

The research demonstrates that the process for calculating and establishing Air Force-level TNMCM standards is not well known across the Air Force and not equally applied across the total force. Also, the process currently in use does not produce realistic, capability-based metrics to drive supportable operational decisions.

The authors conclude by recommending that a repeatable methodology be developed to compute the TNMCM standard so that it:

- Reflects day-to-day minimum operational requirements
- Adjusts to fully mobilized force capabilities and surge mobility requirements
- Accounts for historic capabilities and fleet resources

above O&M flying, average number of aircraft required for standard flying operations each day, required daily spares, and the forecasted number of unit possessed aircraft over the year.

Background

This article is the third in a three-part series based on Air Force Logistics Management Agency (AFLMA) project number LM200625500, the *C-5 TNMCM Study II*. At the request of the Air Force Materiel Command Director of Logistics (AFMC/A4), an AFLMA study team conducted an analysis in 2006-2007 of TNMCM performance with the C-5 aircraft as the focus. The *C-5 TNMCM Study II* included five objectives. One of those objectives was to analyze the process for calculating and establishing aircraft TNMCM standards. This article details the analysis conducted in support of that particular study objective.

Maintenance Metric Definitions

Air Force Instruction (AFI) 21-101, *Aircraft Equipment and Maintenance Management*, defines the MC, TNMCS, and TNMCM metrics and their uses. For additional insight on the use of these metrics see *Metrics Handbook for Maintenance Leaders*.

Mission Capable (MC) Rate

Though a lagging indicator, the MC rate is perhaps the best known yardstick for measuring a unit's performance. It is the percentage of possessed hours for aircraft that are fully mission capable (FMC) or partially mission capable (PMC) for specific measurement periods (such as monthly or annually).[1]

$$\text{MC (\%)} = \frac{\text{FMC Hours + PMC Hours}}{\text{Possessed Hours}} \times 100\%$$

Total Not Mission Capable Maintenance (TNMCM) Rate

Though a lagging indicator, the TNMCM rate is perhaps the most common and useful metric for determining if maintenance is being performed quickly and accurately. It is the average percentage of possessed aircraft (calculated monthly or annually) that are unable to meet primary assigned missions for maintenance reasons (excluding aircraft in *B-Type* possession identifier code status). Any aircraft that is unable to meet any of its wartime missions is considered not mission capable. The TNMCM is the amount of time aircraft are in NMCM plus not mission capable both (NMCB) status.[2]

$$\text{TNMCM (\%)} = \frac{\text{NMCM Hrs + NMCB Hrs}}{\text{Possessed Hours}} \times 100\%$$

Total Not Mission Capable Supply (TNMCS) Rate

Though this lagging metric may seem a logistics readiness squadron responsibility because it is principally driven by availability of spare parts, it is often directly indicative of maintenance practices. For instance, maintenance can keep the rate lower by consolidating feasible cannibalization actions to as few aircraft as practical. This monthly (annual) metric is the average percentage of possessed aircraft that are unable to meet primary missions for supply reasons. The TNMCS rate is the time aircraft are in not mission capable supply (NMCS) plus not mission capable both maintenance and supply (NMCB) status. TNMCS is based on the number of airframes out for mission capable (MICAP) parts that prevent the airframes from performing their mission (NMCS is not the number of parts that are MICAP).[3]

$$TNMCS\ (\%) = \frac{\text{NMCS Hrs} + \text{NMCB Hrs}}{\text{Possessed Hours}} \times 100\%$$

Fiscal Year (FY) 2007 C-5 Fleet Standards and Standards Calculations

As previously mentioned, during a 2003 CORONA, the Air Force Chief of Staff (CSAF) directed the establishment of Air Force-wide standards for the MC, TNMCS, and TNMCM metrics. Headquarters (HQ) Air Force Instalations and Logistics (now AF/A4) was named the office of primary responsibility (OPR). Their charter was to develop Air Force standards rooted in operational requirements and resources dedicated to each weapon system or mission design series (MDS). They subsequently developed calculation methodologies for calculating MC, TNMCS, and TNMCM standards. However, as of the time of the original study research, the study team found no official publication documenting the methodology for calculating these maintenance metric standards. Consequently, OPRs at the HQ Air Force and MAJCOM levels provided the study team with the definitions for the calculation methodologies that produced the C-5 fleet maintenance standards used in FY 2007. Table 1 summarizes the 2007 C-5 standard percentage rates for the MC, TNMCS and TNMCM metrics. An explanation of each method for deriving the standards follows.

MC Standard

The MC standard provides the foundation for calculating the other maintenance metric standards. According to HQ Air Force, Directorate of Maintenance, Weapons Systems Division, Sustainment Branch (AF/A4MY) personnel, the MC standards are based on requirements. The MC standard represents the percentage of MC aircraft required at the beginning of each flying day. That requirement is determined by one of the following three ways:[5]

- The flying hour or flying schedule requirement, calculated using Equation 1, 2, or 3.
- Contract logistics support (CLS) contract.
- Some other requirement based on MAJCOM input. That input can be a DOC statement, readiness study, or any operational requirement the MAJCOM may use.

The Air Reserve Component (ARC), a composite of both ANG and AFRC, MC standard is based on the number of aircraft committed to the flying schedule. However, the ANG flying commitment is based on O&M flying hours, transportation working capital fund (TWCF) hours, and the number of operations alert committed aircraft per flying day. Also included is the daily spares requirement. This commitment in aircraft is divided by the forecasted possessed aircraft to determine the MC requirement.[6]

Each year, AF/A4MY personnel request input from AMC for the MC standard. AMC determines the MC rate necessary to meet their airlift requirement and then gives their desired MC rate to Air Staff. Air Staff then uses this rate as the MC standard. This process is currently used to determine the active duty MC standards for the C-17, C-5, C130, KC-10, and KC-135 airframes.[7] These MC standards are based solely on AMC's input. AF/A4MY personnel do not calculate the MC standard for any of the above listed active duty fleets.

Article Highlights

Article Acronyms

AA – Aircraft Availability
AAT – Aircraft Availability Target
AC – Aircraft
ACC – Air Combat Command
AE – Aeromedical Evacuation
AFB – Air Force Base
AFI – Air Force Instruction
AFLMA – Air Force Logistics Management Agency
AFMC – Air Force Materiel Command
AFRC – Air Force Reserve Command
AFSO21 – Air Force Smart Operations for the 21st Century
AMC – Air Mobility Command
ANG – Air National Guard
BE – Business Effort
CLS – Contract Logistics Support
CONOPS – Concept of Operations
CSAF – Chief of Staff, United States Air Force
DOC – Designed Operational Capability
DoD – Department of Defense
FMC – Fully Mission Capable
FY – Fiscal Year
GAO – Government Accountability Office
HQ – Headquarters
LMI – Logistics Management Institute
LRS – Logistics Readiness Squadron
MAJCOM – Major Command
MC – Mission Capable
MCS – Mobility Capabilities Study
MDS – Mission Design Series
MERLIN – Multi-Echelon Resource and Logistics Information Network
MICAP – Mission Capable
MRS – Mobility Requirements Study
NMCB – Not Mission Capable Both
NMCM – Not Mission Capable Maintenance
NMCS – Not Mission Capable Supply
O&M – Operations and Maintenance
OPR – Office of Primary Responsibility
PAA – Possessed Aircraft Authorized
PMC – Partially Mission Capable
REMIS – Reliability and Maintainability Information System
RERP – Reliability Enhancement and Re-Engining Program
TNMCM – Total Not Mission Capable Maintenance
TNMCS – Total Not Mission Capable Supply
TWCF – Transportation Working Capital Fund
UTE - Utilization

		Active Duty	ARC	*AFRC*	*ANG*
MC	Standard	75	50	*50*	*47*
	Method	*MAJCOM Input*	*Equation 3*	*Equation 1*	*Equation 2*
TNMCS	Standard	8	8		
	Method	*Equation 4*	*Equation 4*		
TNMCM	Standard	24	50		
	Method	*Equation 6*	*Equation 6*		

Table 1. FY 2007 C-5 Maintenance Standards and Calculation Methodologies[4]

The three MC standard requirement algorithms are detailed in Equations 1, 2, and 3. Equation 1 is typically used with active duty aircraft fleets.

$$MC_{Std} = \left[\frac{12 \times UTE}{(1 - Attrition) \times (Turn\ Pattern) \times (Fly\ Days)}\right] + \left[\frac{Spares + MC_{SchdMX}}{PAA}\right]$$

Equation 1. MC Standard[8]

Where:

MC_{std} is MC Standard.

UTE is the sortie utilization rate, which is the number of sorties required to fly each month by authorized aircraft. 12 x *UTE* yields the annual sorties required to meet the flying hour program (FHP).

Attrition is the annual attrition rate of sorties lost due to operations, maintenance, and other considerations such as weather. Dividing by (1-*Attrition*) yields the sorties required to be scheduled to account for attrition.

Turn pattern, or turn rate, is the total number of sorties scheduled divided by the number of *first go* sorties. For example: a unit schedules 100 sorties during the week and 60 of them occur on the *first go* of the day. The turn rate would be 100/60 = 1.67. Dividing by *turn pattern* yields the number of front-line flyers. Dividing by the number of *fly days* yields the number of front-line flyers per day.

Fly Days = 232. This figure assumes 244 *working days* minus 12 *goal days*.

Spares, or front line spares, is the number of scheduled spare aircraft for the *first go*.

MC_{SchdMX} is the average number of aircraft per squadron held down on each flying day for scheduled maintenance including delayed discrepancies, health of the fleet management, washes, and so forth.

Spares + MC_{SchdMX} is expressed as a percentage of squadron possessed aircraft authorized (PAA).

PAA is the number of aircraft authorized for a unit to perform its operational missions.[9]

Equation 2 is the algorithm used by the ANG.

$$MC_{ANG} = \left\lceil\frac{\left[AC_{O\&M} + AC_{TWCF/BE/AE} + AC_{Ops} + Spares\right]}{AC_{Forecast}}\right\rceil$$

Equation 2. MC Standard for ANG[10]

Where:

$AC_{O\&M}$ is the average number of committed aircraft based on the O&M requirements per flying day.

$AC_{TWCF/BE/AE}$ is the number of aircraft required for taskings per flying day that the ANG supports above its O&M flying (such as TWCF, aeromedical evacuation (AE), business effort [BE]).

AC_{Ops} is the average number of aircraft required for standard flying operations per flying day.

Spares is the same as in Equation 1, but is reported as the number of aircraft per flying day.

$AC_{Forecast}$ is the number of aircraft that are expected to be unit possessed over the year based on depot maintenance schedules and other considerations.

$\lceil x \rceil$ shown in the numerator of Equation 2 denotes the smallest integer greater than or equal to x. This function rounds any decimal value up to the next whole number. The ceiling function is used in order to speak in terms of whole aircraft.

Equation 3 is utilized to calculate the MC standard for the composite ARC portion of an aircraft fleet.

$$MC_{ARC} = \frac{(MC_{AFRC} \times PAA_{AFRC}) + (MC_{ANG} \times PAA_{ANG})}{PAA_{AFRC} + PAA_{ANG}}$$

Equation 3. MC Standard for ARC Fleet[11]

The MC standard for the AFRC (MC_{AFRC}) fleet is calculated using the standard MC equation given in Equation 1. For simplicity, the result of this formula is rounded to the nearest tenth.

TNMCS Standard

Active duty and ARC fleets use the same methodology for TNMCS once the MC standard is established. This calculation is shown in Equation 4. Note that separate TNMCS standards for AFRC and ANG are not calculated.

$$TNMCS_{Std} = 1 - AAT$$

Equation 4. TNMCS Standard[12]

The aircraft availability target (AAT), ties the TNMCS standard to the funding and requirements for spare parts that are calculated in the Requirements Management System.[13] It assumes the supply pipeline and spare safety levels are fully funded. The *AAT* for the C-5 has been at 92 since the beginning of the maintenance standard development. This yields a TNMCS standard of 8 which is applied to both ARC components.

Equation 5 defines the aircraft availability target calculation.

$$AAT = Required\ MC + NMCM_{3\ year\ historical}$$

Equation 5. AAT Calculation[14]

Required MC is determined the same way that the Air Force active duty MC standard is determined.[15]

$NMCM_{3\ year\ historical}$ is the 3-year historical average of the NMCM rate for the particular MDS under consideration.

It is important to note that the maintenance metrics standards established for FY07 (Table 1) used the FY05 calculated AATs.

This is because the C-5 parts on the shelf in FY07 were based on the FY05 AATs.[16] As just mentioned, the FY05 AAT for the C-5 fleet was 0.92. The Logistics Management Institute (LMI) updated the AAT-setting methodology in 2006 to include computations for *Required MC* and NMCM rates for both day-to-day operations and predeployment.[17]

TNMCM Standard

Active duty and ARC fleets use the same methodology for TNMCM once the respective MC standard is established. This calculation is shown in Equation 6. Note that separate TNMCM standards for AFRC and ANG are not calculated.

$$TNMCM_{Std} = 1 - \left(MC_{Std} + TNMCS_{Std}\right) + NMCB_{3\ yr\ historical}$$

Equation 6. TNMCM Standard[18]

$NMCB_{3\ yr\ historical}$ is the average NMCB rate over the previous 3 years. The data used for the FY07 calculation came from the Reliability and Maintainability Information System (REMIS); the average NMCB for FY04, FY05, and FY06 equaled 0.07.[19]

Standards Calculation Examples

This section applies the above formulas to the real-world data that produced the metric standards in Table 1.

FY07 Active Duty C-5 Fleet

MC Standard (MAJCOM Input):

AMC stated that the MC standard is 0.75 (75 percent) based on an operational requirement used in the Mobility Requirements Study (MRS) 2005 (MRS-05).

TNMCS Standard (Equation 4):

$$TNMCS_{Std} = 1 - AAT = 1 - 0.92 = 0.08$$

TNMCM Standard (Equation 6):

$$\begin{aligned} TNMCM_{Std} &= 1 - \left(MC_{Std} + TNMCS_{Std}\right) + NMCB_{3\ yr\ historical} \\ &= 1 - (0.75 + 0.08) + 0.07 \\ &= 0.24 \end{aligned}$$

FY07 ARC C-5 Fleet

The data required to calculate the ARC standards for FY07 is given in Table 2. AFRC and ANG provided the data in response to the FY07 Air Force Standards Data Call.

The PAA numbers the commands provided were 32 for the AFRC and 16 for the ANG. These values reflected the PAA before the PAA was adjusted to accommodate units recently gaining C-5s. To compute the AFRC MC standard, AF/A4MY used the PAA based on AFRC input, which was 32. However, for the weights in determining the composite ARC MC standard, AF/A4MY used the PAAs for FY07, which included the additions for the gaining units. These values are 40 for AFRC and 29 for ANG.

AFRC MC Standard (Equation 1):

$$MC_{AFRC} = \left[\frac{12 \times UTE}{(1 - Attrition) \times (Turn\ Pattern) \times (Fly\ Days)}\right] + \left[\frac{Spares + MC_{SchdMX}}{PAA}\right]$$

$$MC_{AFRC} = \left[\frac{12 \times 8.5}{(1 - 0.23) \times (1.3) \times (232)}\right] + \left[\frac{2 + 0}{32}\right] = \left[\frac{102}{232.232}\right] + \left[\frac{2}{32}\right] = 0.502$$

ANG MC Standard (Equation 2):

$$\begin{aligned} MC_{ANG} &= \left[\frac{\left[AC_{O\&M} + AC_{TWCF/BE/AE} + AC_{Ops} + Spares\right]}{AC_{Forecast}}\right] \\ &= \left[\frac{\left[3.84 + 1.19 + 0.45 + 1.3\right]}{15}\right] \\ &= \left[\frac{\left[6.78\right]}{15}\right] = \left[\frac{7}{15}\right] = 0.47 \end{aligned}$$

ARC MC Standard (Equation 3):

$$\begin{aligned} MC_{ARC} &= \frac{(MC_{AFRC} \times PAA_{AFRC}) + (MC_{ANG} \times PAA_{ANG})}{PAA_{AFRC} + PAA_{ANG}} \\ &= \frac{(0.50 \times 40) + (0.47 \times 27)}{67} = 0.488 \approx 0.50 \end{aligned}$$

TNMCS Standard (Equation 4):

$$TNMCS_{Std} = 1 - AAT = 1 - 0.92 = 0.08$$

TNMCM Standard (Equation 6):

$$\begin{aligned} TNMCM_{Std} &= 1 - \left(MC_{Std} + TNMCS_{Std}\right) + NMCB_{3\ yr\ historical} \\ &= 1 - (0.50 + 0.08) + 0.08 \\ &= 0.50 \end{aligned}$$

Of note is the fact that the 3-year average NMCB was actually 0.166 (based on Multi-Echelon Resource and Logistics Information Network [MERLIN] data). AF/A4MY capped the NMCB at 0.08 because the historical NMCB cannot theoretically exceed the TNMCS. Recall that TNMCS is the sum of NMCS and NMCB; therefore, NMCB *should be* less than or equal to TNMCS.[21] The TNMCS standard is established as a resourced goal and the Air Force is trying to achieve a balance in the maintenance standards.[22]

AMC Determination of the C-5 MC Operational Requirement

According to AF/A4MY and AMC/A4MXA, AMC provides Air Staff with the value for the MC standard for the active duty fleet. This standard has been 75 percent since 2003, the year that Air Force-wide standards were implemented.[23] AMC/A4MXA stated that the value of 75 percent was based on the MRS.[24] According to the AMC/A9 office, every major mobility study including the MRS (1992), the *MRS Bottom-Up Review Update* (1995), MRS-05 (2000), and the *Mobility Capabilities Study* (2005), has used 75 percent as the C-5 MC rate standard to

	PAA Command Input	PAA (FY07 Actual)	UTE	Attrition	Turn Pattern	Fly Days	Spares	MC for Sched Mx
AFRC	32	40	8.5	0.23	1.3	232	2	0
	PAA Command Input	PAA (FY07 Actual)	O&M AC/day	TWCF,BE, AE AC/day	Spares/ day	Ops AC/day	Possessed AC Forecast	
ANG	16	27	3.84	1.19	1.3	0.45	15	

Table 2. Data for AFRC and ANG MC Standard Calculations[20]

determine the capability of the C-5 fleet to support the mobility forces.[25]

Examination of the MRS-05 revealed the MRS-05 did not calculate an MC standard; the MRS-05 assumed an MC rate of 76 percent for a fleet in which all C-5s have had the Reliability Enhancement and Re-Engining Program (RERP) modifications. The MRS-05 explains that the use of 76 percent MC rate is because of expected RERP improvements. The study also assumes a 65 percent MC rate for aircraft that have not received the RERP improvements.[26] The director of the AMC office of Analysis, Assessments, and Lessons Learned (AMC/A9) concurred that the C-5 MC standard is not based on any formal calculation or analysis, and stated that the original estimate (circa 1990) of a 75 percent MC rate was deemed "a prudent objective" for planning purposes.[27] AMC/A9 stated that the 75 percent MC rate assumes a fully mobilized total force to support C-5 maintenance operations.[28]

In summary, the FY07 MC, TNMCS, and TNMCM standards for the C-5 active duty fleet are based on the assumption that the C-5 fleet can achieve a 75 percent MC rate with the entire fleet receiving RERP upgrades or a fully mobilized total force to support maintenance operations.

Implications of the Methodology

There are numerous implications of this complex, seemingly disjointed standards methodology that are problematic for Air Force members at the strategic, operational, and tactical levels. First, Equation 1, in its present state, is more appropriate for fighter aircraft than mobility aircraft.[29] For example, the *Turn Pattern* and MC_{SchdMX} variables are reflective of fighter aircraft flying schedules. Mobility aircraft are less often *turned* on the same flying day, and mobility aircraft units, having a relatively small number of PAA, often have less opportunity to hold aircraft down for fleet health purposes. Consequently, this is a contributing factor to AF/A4MY's rationale of using AMC's input to determine active duty standards. The study team concluded that if Equation 1 is not appropriate for heavy aircraft, then it should not be used as a foundation for the MC standard. The variables used to measure performance need to accurately reflect the relevant process.

An additional issue is a lack of consistency across the total force components. The active duty component uses AMC input to determine the MC standard, but the ARC uses calculation methodology. Moreover, in addition to the planning objective used to determine the active duty maintenance standards and the calculations used to determine the ARC standards, the total force components, including the ANG, have maintenance metric goals. These goals are separate from the Air Force standards and are calculated differently. Within the ANG, units report their performance with regard to the ANG goals, and not necessarily the ARC metric standards. While the functional mission differences between fighter and mobility aircraft may justify distinct calculation methodologies, inconsistencies within a given airframe (for example, the C-5) are less easily supported. Consistency, in fact, is identified by AFI 21-101 as one of four important characteristics of a metric. These four characteristics are:

- Accurate and useful for decisionmaking
- Consistent and clearly linked to goals or standards
- Clearly understood and communicated
- Based on a measurable, well-defined process[30]

The fourth characteristic mentioned above highlights another concern given the current methodology for calculating the C-5 standards. Fundamentally, the process is not rigidly followed as part of formal policy; rather, the practice of establishing standards involves numerous deviations, discussed at length earlier in this article (active duty MC input, AAT from FY05, ANG goals). Simply stated, there was no complete, published, defined process. In April 2003, the United States Government Accountability Office (GAO) discussed these same issues in a report addressing aircraft availability goals across the Department of Defense (DoD).[31] The GAO found that all branches of military Service fail to clearly define the standards computation process for aircraft maintenance metrics.

The following selected comments were taken from the GAO report's executive summary:

> Despite their importance, DoD does not have a clear and defined process for setting aircraft availability goals. The goal-setting process is largely undefined and undocumented, and there is widespread uncertainty among the military Services over how the goals were established, who is responsible for setting them, and the continuing adequacy of MC and FMC goals as measures of aircraft availability. DoD guidance does not define the availability goals that the Services must establish or require any objective methodology for setting them. Nor does it require the Services to identify one office as the coordinating agent for goal setting or to document the basis for the goals chosen.[32]

Speaking in terms of consequence, the GAO suggested that the "lack of documentation in setting the goals ultimately obscures basic perceptions of readiness and operational effectiveness."[33] Additionally, the report documented several findings specifically relevant to establishing standards for the Air Force. These findings included:

- Air Force officials told [the GAO] that they generally try to keep the goals high because it is difficult to stop the goals from dropping further once they begin to be lowered.[34]
- Air Combat Command could find no historical record of the process used to establish most of the goals.[35]
- AMC compared the goals with the actual rates for the previous 2 years. Depending upon actual performance, the goal could then be changed, sometimes on the basis of subjective judgments.[36]

It is vitally important to examine the effectiveness and validity of metrics and their associated standards. Many hours are spent preparing for and participating in meetings discussing the performance of organizations, all of which is wasted if the metrics or standards are ineffective at measuring organizational performance and driving the desired behavior. Budgets and other requirements are driven in part from metrics. If the metrics being utilized are not valid, the effectiveness of the organization to meet warfighter needs is also difficult to accurately measure.

Air Force maintenance metrics are presented with an associated numerical standard or goal[37] and managers are required to account for failure to meet those standards. These failures are reported at unit, command, and Air Force levels, but what if the established standard is inaccurate, unrealistic, or unattainable? Consider Table 3, which identifies historical MC performances

for the C-5 at various points in time compared with the assumption used in establishing the C-5 MC standard.

During Operations Desert Shield and Desert Storm in FY91, the MC rate was less than 71 percent. During Operation Iraqi Freedom in FY03, the MC rate was less than 64 percent. This is particularly intriguing because numerous personnel interviewed during the original research suggested MC rates have been or should be usually better during conflicts.[39] Indeed, the highest quarterly MC rate the C-5 total fleet achieved, 81.8 percent, was observed during first quarter of FY91 (during Operation Desert Shield). Considering the data points in Table 3 are rates achieved during wartime scenarios, the feasibility of using 75 percent as the day to day, peacetime C-5 MC standard appears questionable at best.

Still, consistent failures to meet a standard can often be perceived as a shortfall in the performance of the units supporting the C-5, rather than an unrealistic expectation not being met. Again, a tremendous amount of time and effort is put forth explaining why standards are not met. Historical C-5 MC rate performance would suggest that the standard and its associated metric are not driving improvement in performance, which is the fundamental purpose of a performance measure. A metric and its associated standard should drive performance, not simply document it, and the measure should be useful for decisionmaking. Additionally, the *Air Force Smart Operations for the 21st Century Concept of Operations (CONOPS)* identifies good process metrics as having the following attributes:[40]

- Accurate – reliably expresses the phenomenon being measured
- Objective – not subject to dispute
- Comprehensible – readily communicated and understood
- Easy – inexpensive and convenient to compute
- Timely – data sources are available
- Robust – resistant to being gamed and hard to manipulate[41]

As previously stated, the current standards methodology involves differences across the total force. Additionally, the study team interviewed many subject matter experts while conducting site visits for this research. Some of them indicated the consistent inability to achieve an MC standard of 75 percent led to an attitude of frustration, indifference and apathy towards the standards.[42] AFI 21-101 states that "metrics shall be used at all levels of command to drive improved performance."[43] In the case of the C-5, the existing maintenance standards methodology associated with the MC and TNMCM metrics appear to cause those metrics to fall short of this goal.

Alternative Strategies to Performance Measurement

As described in the second article in this series, the AFLMA study team interviewed representatives from the Delta Airlines reliability programs office as a means of comparing business practices. Delta personnel identified nine main aircraft maintenance metrics. Of note was the fact that Delta's primary metrics (those driven by delays and cancellations) were not measured to an objective standard (met or not met); instead, they alert when they exceed a control limit for 2 consecutive months.[44]

Using control limits, found in control charts, is a commonly used technique for determining if a process is in a state of statistical control. First developed by Shewhart, many influential quality leaders have advocated the proper use of control charts, most notably W. Edwards Deming. Generally speaking, recent data is examined to determine the control limits that apply to future data with the intent being to ascertain whether the process is in a state of control.[45] Charts alone cannot induce process control; stabilization or improvement is the challenge of people in the process.[46] Viable control limits can only be developed for processes in a state of statistical control, and they are best applied to process variables rather than product variables.[47] For example, consider the manufacturing process of a metal component. The product variables might be thickness or diameter, whereas process variables could be temperature or pressure at the point of forging. The benefit of monitoring process variables better allows someone to assign cause to variation. Using the previous example, variance in component diameter indicates a problem but requires further investigation to determine the cause. However, excessive pressure measurements identify the cause behind improper component diameter. Essentially, process variable measurements identify causes that could affect product variables.[48]

Today, many maintenance units are using versions of control charts to monitor performance in terms of the various metrics listed in AFI 21-101.[49] For example, Figure 1 illustrates TNMCM performance (large solid black line), with upper and lower control limits (represented by the solid red lines), at Dover Air Force Base (AFB) during calendar year 2006. Although the effort to use control charts is a step in the right direction, there can be two major problems associated with the use of charts akin to those of Figure 1.

First, Air Force metric measurements such as TNMCM are not process variables; consequently, they do not lend themselves to the immediate, precise root-cause analysis that usually follows from control charts. This is evidenced by the copious explanatory notes pages accompanying products like the CSAF quarterly review slideshow.[51] In fact, the *C-5 TNMCM II* study team's analytical effort identified 184 factors that bear influence on the C-5 TNMCM rate. An additional confounding element is that status of aircraft and the categorization of hours (such as *possessed*) bear direct influence on the outcome of rates such as TNMCM, and this process is not consistent. Study team discussions with maintenance personnel revealed that aircraft status is not an exact science, and status documentation can be vulnerable to manipulation for the sake of improving numbers. For example, this can happen by delaying aircraft status changes

	MC Rate	Time Period
AMC C-5 MC Standard	75%	~1990 – Present[38]
Operation Desert Shield/Desert Storm	70.6%	Fiscal Year 1991
Operation Iraqi Freedom	63.4%	Fiscal Year 2003
Highest Quarterly MC Rate Achieved	81.8%	Fiscal Year 1991, Quarter 1

Table 3. C-5 Fleet Historically Achieved MC Rates[38]

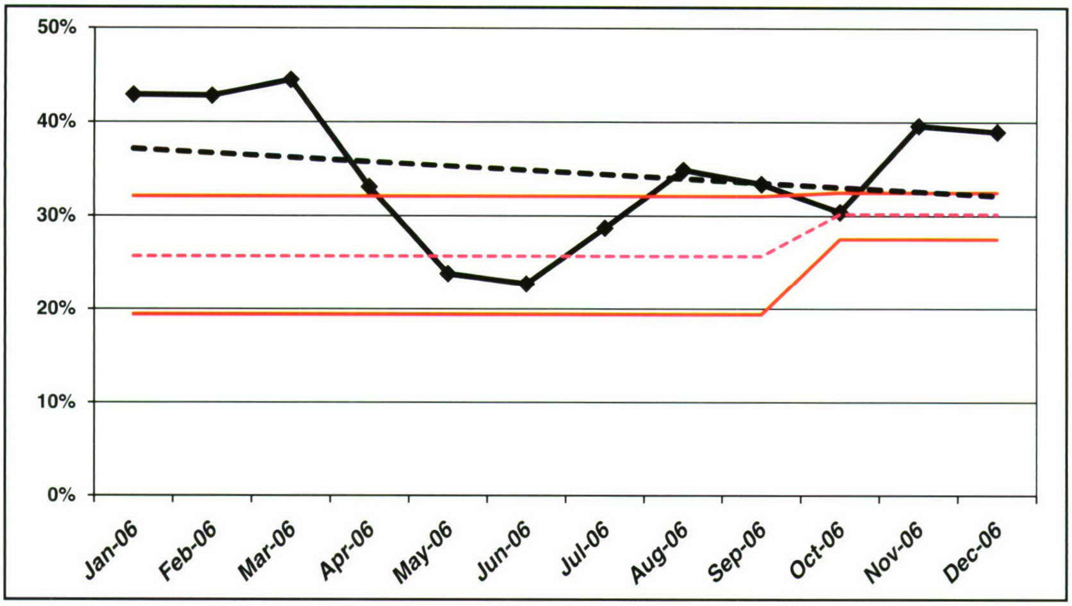

Figure 1. Example of TNMCM Control Chart, Dover AFB 2006[50]

by not changing the status to NMCM or NMCS as soon as an aircraft breaks and maintenance is underway or work stoppage occurs due to needed parts.

The categorization of hours is something that is in stark contrast with the host of metrics used by Delta Airlines, which upon examination appeared more tangible, more easily measured, and less easily manipulated. Again, a thorough discussion of Delta's maintenance metrics was included in the second Air Force Journal of Logistics article in this series.

Next, upon examination of the control chart in Figure 1, one sees that the centerline mean (small dashed line between the solid red lines) is set at 30.2 for the months in FY07, with the upper and lower control limits set at 32.5 and 27.5, respectively.[52] The study team sought to uncover the specific methodology used to arrive at the centerline mean, as well as the upper and lower control limits. Personnel at Dover stated that the control limits are downward directed from headquarters AMC. The managing office at AMC stated that the control limits were derived from 2 years of historical data for all of AMC, with a range of one standard deviation above and below the mean.[53] There are two issues with this approach. First, the figure is not arrived at through subgroup sampling of at least 20 subgroups, as advocated by statistical analysis literature.[54] Secondly, this centerline mean is known as the *AMC goal* for the TNMCM rate. Interestingly, it is higher (that is, less ambitious) than the active duty TNMCM standard, which was 24 for the FY07 timeframe. The fact that AMC units are using a different figure than the established active duty standard for management purposes is further evidence that fleet standards appear to have limited influence on performance at base levels.

However, as noted in the 2005 AMC Metrics Handbook, because AMC command goals are rooted in wartime operational requirements, there are some standards that are difficult or impossible to achieve during peacetime operations.

> Using the *command average* is one way around this shortcoming. Comparing (your base) to command averages helps to gauge true performance and is invaluable for identifying if a problem is local or fleet wide. AMC weapons system managers (WSMs) use command averages for understanding overall performance of their fleets. When discussing performance problems with AMC WSMs, base personnel should have a good understanding of where their base performance numbers are in relation to the command average.[55]

It should be noted that the study team was not advocating the use of the active duty standard as the centerline mean for this control chart. In fact, extreme caution must be taken when using a standard value as opposed to the sampling mean as the centerline for performance. Although the intent might be to control the process mean at a particular value, one runs the risk that the current process is incapable of meeting that standard. For example, if the lower and upper control limits are calculated from the standard, and the current process mean exceeds the standard, subgroup averages might often exceed the upper limit, even though the process is in control. This lessens the ability to determine assignable causes of variation, because the only observation is that the process isn't conforming to the desired value.[56] This may, in fact, be what was actually occurring with the MC metrics for the C-5 fleet.

What Should the TNMCM Standard Be?

If the existing standard's equations were used with current C-5 aircraft data (rather than using the 75 percent MC input from AMC for the active duty fleet) to calculate the active duty fleet MC, TNMCS, and TNMCM standards, the resulting standards[57] would be:

- MC Standard = 56.8
- TNMCS Standard = 20.6
- TNMCM Standard = 29.3

These figures are presented for informational purposes only in order to illustrate the stark contrast with the active duty standards in place at the time of the original report's publication (MC = 75, TNMCS = 8, and TNMCM = 24). The study team was not advocating the use of the standards presented above. Instead, the examination presented here and in the study report led to the recommendation that AMC and Air Staff develop a repeatable methodology to compute a standard focused on three things. These three things are listed in the recommendations section of this article. Such a methodology would better align to the original charter from the 2003 CORONA, which was to develop Air Force standards rooted in operational requirements and resources dedicated to the weapon system or MDS.

Conclusions

The process for calculating and establishing Air Force-level TNMCM standards is not well known across the Air Force and

not equally applied across the total force. Also, the process currently in use does not produce realistic, capability-based metrics to drive supportable operational decisions.

Recommendations

Develop a repeatable methodology to compute the standard that:

- Reflects day-to-day minimum operational requirements
- Adjusts to fully mobilized force capabilities and surge mobility requirements
- Accounts for historic capabilities and fleet resources

As previously mentioned, the analysis of maintenance metric standards described in this article was developed as part of the larger *C-5 TNMCM Study II*. This is the third and final article in a series related to that particular research. The entire study report can be found at the Defense Technical Information Center private Scientific and Technical Information Network Website at https://dtic-stinet.dtic.mil/.

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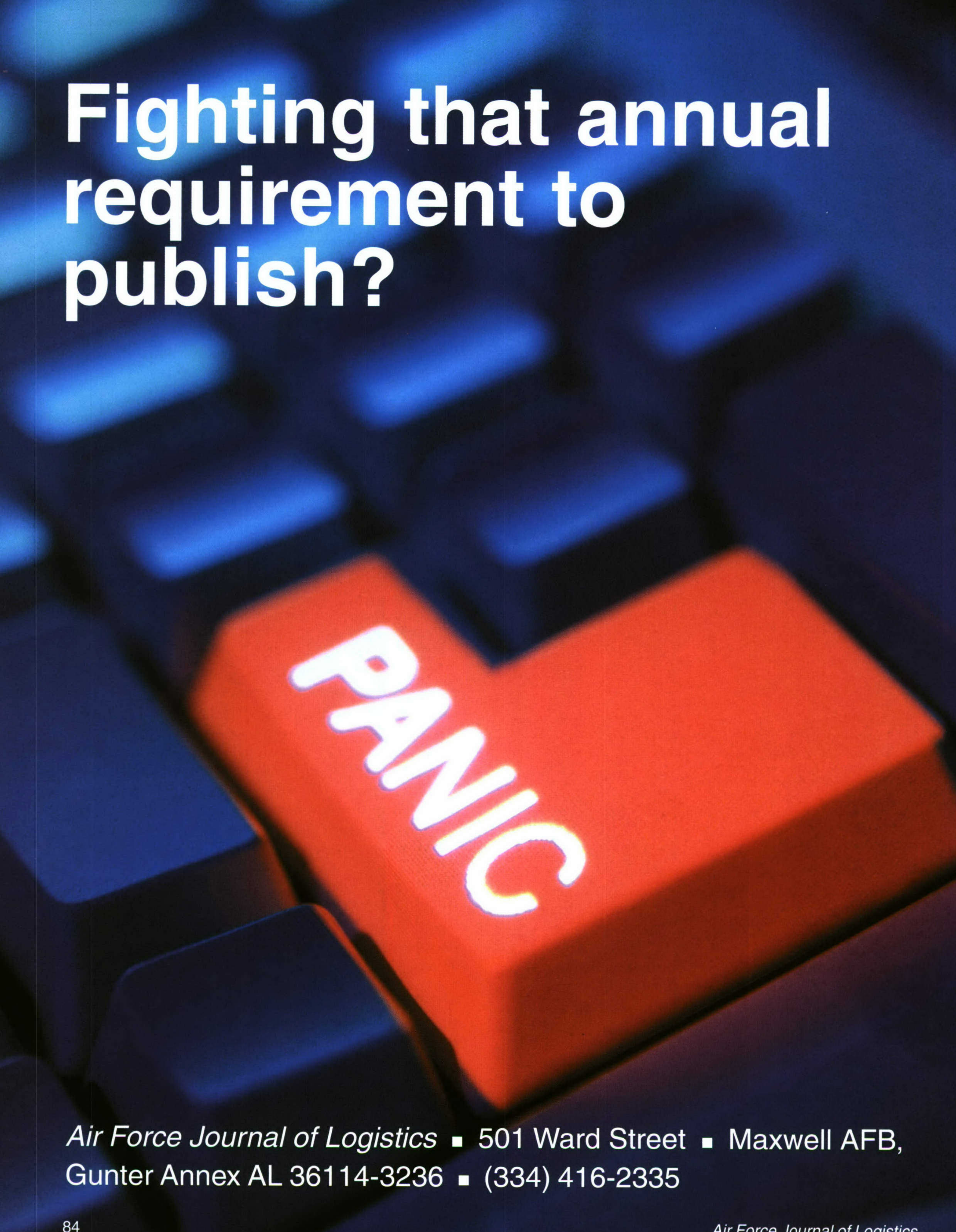

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The earned value concept was developed to correct serious distortions in assessing a project's cost performance generated by comparing actual costs with a time-phased budget.

contemporary issues

Earned Value Management: Uses and Misuses

This edition's Contemporary Logistics feature was written by Dr Stephen Hays Russell. Over the years, Dr Russell has been a frequent contributor to the Journal. He is an accomplished logistician and is on the faculty of the John B. Goddard School of Business and Economics, Weber State University. In "Earned Value Management: Uses and Misuses," Dr Russell examines the relevance of Earned Value Management (EVM) to the logistics community. He makes the case that its relevance is threefold. First, today's logisticians are intimately involved in the weapon system acquisition process. Because EVM is such an integral part of the imposed acquisition management architecture, logisticians need to understand the tool. Otherwise, they become tangential to the management and performance reviews of an acquisition program. Second, EVM is increasingly being addressed in the literature of performance based logistics and acquisition logistics. Third, EVM as a leading-edge management tool has not seen the application to logistics-specific projects that it merits.

He concludes with the following points:

- A basic understanding of EVM is important to the logistician, not only because of its intrinsic value to the management of any complex project, but because it is now widely employed in the procurement-program management community of which logistics is a part.
- EVM is able to provide a true picture of a project's cost performance by accounting for differences between work accomplished and work scheduled. A number of metrics are employed for variance calculations, performance indices, and projections at completion.
- Originally developed as a financial management tool, EVM has become a project management tool for cost, schedule, and scope management. However, this broader approach to EVM generates potential for misuse when the schedule metrics of EVM are used to the exclusion of true schedule management tools. In addition, estimate at completion calculations with EVM metrics should be employed judiciously lest misleading projections arise given the circumstances of any particular project.

Stephen Hays Russell, PhD, Weber State University

Earned Value Management

uses and misuses

Originally developed as a financial management tool, earned value management (EVM) has become a project management tool for cost, schedule, and scope management. However, this broader approach to EVM generates potential for misuse when the schedule metrics of EVM are used to the exclusion of true schedule management tools. In addition, estimate at completion calculations with EVM metrics should be employed judiciously lest misleading projections arise given the circumstances of any particular project.

Introduction

Earned Value Management was originally developed by the United States Air Force as a financial management tool. Over the years, the earned value technique has matured into a significant project management tool with particular application to the acquisition of weapon systems.

The relevance of EVM to the logistics community is threefold. First, today's logisticians are intimately involved in the weapon systems acquisition process. Because EVM is such an integral part of the imposed acquisition management architecture, logisticians need to understand the tool. Otherwise, they become tangential to the management and performance reviews of an acquisition program. Second, EVM is increasingly being addressed in the literature of performance based logistics (PBL) and acquisition logistics.[1] Third, EVM as a leading-edge management tool has not seen the application to logistics-specific projects that it merits.[2]

Many logisticians have low familiarity with this important management tool. This article examines the conceptual underpinnings of the EVM methodology and its applicability to measuring a project's performance, with particular emphasis on its uses and misuses.

Background of EVM

The earned value concept was developed to correct serious distortions in assessing a project's cost performance generated by comparing actual costs with a time-phased budget. Consider Figure 1, which plots both a time-phased budget (the spend plan) and cumulative actual expenditures to date. Note that at Time $_{Now}$, actual expenditures are below budget. Cost performance *appears* favorable.

The problem, of course, is this approach fails to consider what work has been done. The cumulative budget at Time $_{Now}$ may contemplate the completion of more tasks than have actually been accomplished. If this is the case, the favorable cost variance could be illusionary.

A more accurate assessment—one that ties budget to tasks actually completed—is possible with the time-phased program plan illustrated in Table 1. Here four tasks have been scheduled to date for a total Time $_{Now}$ budget of \$152K. Actual expenditures to date are \$128K. However, only Tasks A, B, and C have been accomplished. Hence, comparing the \$128K actually spent to the \$152K spend plan does not make sense. Why? Because this

Article Acronyms

ACWP – Actual Cost of Work Performed
BAC – Budget at Completion
BCWP – Budgeted Cost of Work Performed
BCWS – Budgeted Cost of Work Scheduled
CAP – Control Account Plan
CPI – Cost Performance Index
CV – Cost Variance
DoD – Department of Defense
EAC – Estimate at Completion
EVM – Earned Value Management
PBL – Performance Based Logistics
SPI – Schedule Performance Index
SV – Schedule Variance

program is behind schedule. Task D has not been accomplished as of Time_{Now}. The *earned value* to date—earned in the sense that the tasks have been performed—is $120K. Clearly, we should compare expenditures to date to the earned value. With this comparison, we correctly determine that this project is $8K over budget ($128K spent less $120K budgeted for the tasks actually completed), whereas the spend plan approach suggested by Figure 1 would erroneously conclude this program is under budget by $24K ($152K - $128K). This earned value concept is at the heart of EVM.

The following discussion illustrates that EVM brings together the scope, budget, and cost dimensions of a project and generates metrics for planning, measurement, and control.

EVM Techniques

Earned Value Management requires four pieces of information:

- A baseline plan that defines the project in total
- The tasks planned to be accomplished at Time_{Now}
- The budgeted value of the tasks accomplished by Time_{Now}
- Actual costs at Time_{Now}

The baseline plan is the entire project defined by objectives, tasks, and budget. The aggregated budget for all tasks is called the budget at completion (BAC) and represents the approved funds or the budget constraint for the entire project.

The sum of all tasks in the baseline plan you planned to have accomplished at Time_{Now} in budgeted dollars is called the budgeted cost of work scheduled (BCWS) in EVM terminology. BCWS is the planned value. In Table 1 this value is $152K.

Task	Budget	Status	Actual
A	$40K	Done	$42K
B	$60K	Done	$60K
C	$20K	Done	$26K
D	$32K	Pending	
Total at Time_{Now}	$152K		$128K

Table 1. Tasks Scheduled Through Time_{now}

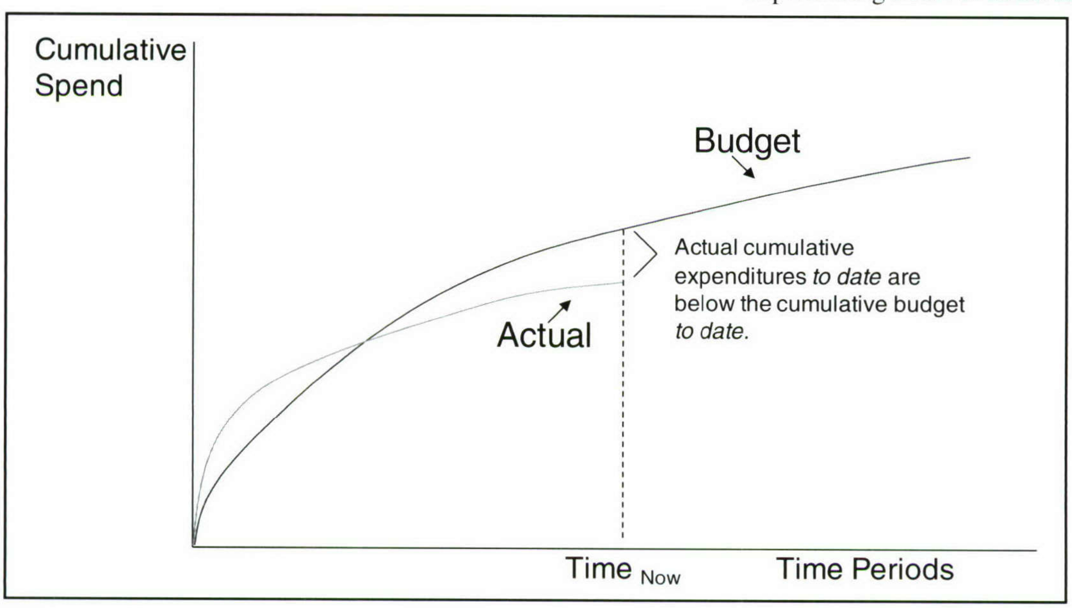

Figure 1. The Spend Plan Approach

The budgeted value of the tasks actually completed at Time_{Now} is the earned value to date and is called the budgeted cost of work performed (BCWP). In Table 1 this value is $120K.

How much you have actually spent to date is called actual cost of work performed (ACWP). In Table 1 this value is $128K.

As suggested earlier, the key piece of information in EVM and the basis for the EVM technique is the earned value, which is BCWP. In all EVM analysis, BCWP is a benchmark number for variance and performance measures.

The Metrics of Performance Measurement

The difference between BCWP and ACWP (that is, the difference between the budgeted cost through Time_{Now} and the actual cost at Time_{Now} for the work performed) is the cost variance (CV). In the Table 1 example, CV is -$8K ($120K - $128K).

The difference between BCWP and BCWS (that is, the difference between the work you have performed and the work you have scheduled through Time_{Now} on a budgeted basis) is schedule variance (SV). In Table 1, SV is $-32K ($120K - $152K).

These performance measurements are expressed formally as:

1. CV = BCWP - ACWP
2. SV = BCWP - BCWS

Note that in both CV and SV calculations the benchmark for measurement is the *earned value*—that is, the BCWP. For these variance measures, positive values portray the project as doing better than planned. Specifically, if for work performed, *actual cost* is less than *budgeted cost*, CV is positive—meaning actuals are less than budget, a favorable condition. For SV, if on a budgeted basis *work performed* is greater than *work scheduled*, a positive value means the project is ahead of schedule. Similarly, negative values portray unfavorable conditions.

Consider Figure 2. BCWP or earned value (the work actually performed on a budgeted basis) is ahead of BCWS (the work scheduled on a budgeted basis) at Time_{Now}. This project is ahead of schedule. However, for the work performed, actual cost at Time_{Now} (ACWP) exceeds the budgeted cost (BCWP). This project is experiencing a cost overrun. Indeed, in this example, actual cost will soon reach the BAC constraint—the cumulative BCWS for the whole project. Clearly, action is required by the program manager.

Performance can also be expressed in terms of ratios. The ratio of BCWP to ACWP is the cost performance index (CPI):

3. CPI = BCWP/ACWP

The ratio of BCWP to BCWS is the schedule performance index (SPI).

4. SPI = BCWP/BCWS

For these ratio measures, values greater than 1.0 mean performance is favorable (better than the plan).

Implementing EVM

EVM can be successfully employed in varying degrees of formality and in projects of all sizes. Examples of potential logistics applications of EVM include a complex logistics research project, development and implementation of new software, design and construction of a new maintenance facility, or any other complex project whose plan consists of discrete, time-phased tasks.

Implementation requires the establishment of detailed processes to collect baseline data and to reliably measure performance and cost. For Department of Defense (DoD)-compliant systems (that is, for EVM systems of private sector firms to qualify for defense contracts), the implementation must satisfy 32 official structural and measurement criteria jointly developed by the federal government and industry.[3]

The first step in implementation is identifying the total scope of work that defines the project and creating a master schedule and a budget for project accomplishment. This step defines the scope baseline in tasks, time, and dollars. The scope baseline is the time-phased BCWS, the project's planned value. The project's total budget (the BAC) is the BCWS for the whole project.

Next, the baseline is broken down into miniature project plans called control account plans (CAPs) (see Figure 3). Each CAP will have a programmed start and completion date, an assigned hour and dollar budget, and assigned resources including a manager accountable for accomplishment.

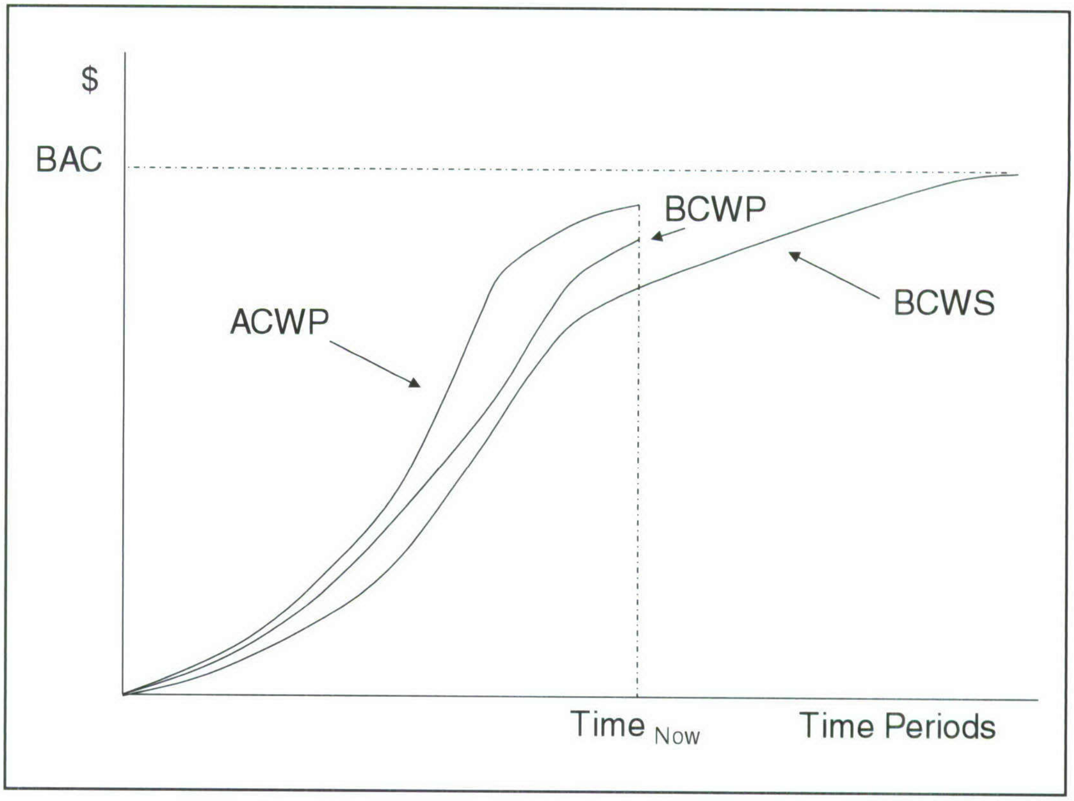

Figure 2. Illustration of EVM Metrics

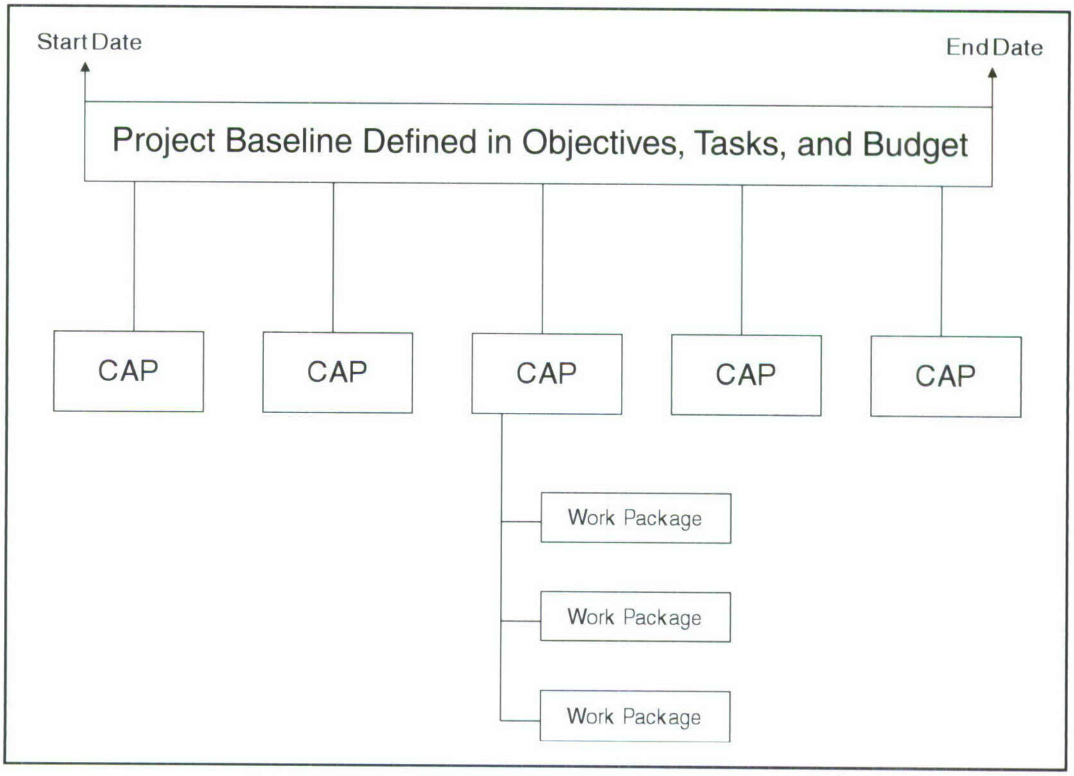

Figure 3. Data and Measurement Structure for Implementing EVM

CAPs are, in turn, disaggregated into discrete work packages. It is at the work package level where earned value is measured and reported at the CAP and ultimately the project level.

The work package level is the genesis for a bottom-up approach to program performance in terms of BCWS, BCWP, and ACWP. Once the project has begun, performance measurement and variance analysis is launched at the work package level and rolled up into the CAP and total program level.

Uses and Misuses of EVM

To illustrate the uses and potential misuses of EVM, consider the metrics portrayed in Figure 4. At $Time_{Now}$, ACWP exceeds BCWP. The distance CV represents cost overrun to date.

Figure 4 also shows BCWP below BCWS. On a dollarized basis, this program is behind schedule by the amount of SV.

The time dimension of the behind-schedule condition (labeled *Time Variance* in Figure 4) is illustrated by the horizontal distance between BCWS and BCWP. At $Time_{Now}$, the dollar value of work performed (BCWP) should have been achieved at the time period indicated by that same value on the BCWS line.

These performance measures serve the following purposes:

- They can serve as an early warning to the program manager that this program is in trouble. In the Figure 4 example, both variance measures are negative, meaning this program is both behind schedule and over on cost.
- Managers can *drill down* to CAPs and work packages in the EVM database to identify areas and root causes of schedule slippage and cost overruns.
- Constructive actions can be taken as EVM metrics indicate deviations from plan. Actions may include correcting inefficiencies that caused the deviations, the recognition that initial budgets were inadequate for the scope of work programmed, or the application of additional resources to bring the project back on schedule. Conversely, unfavorable schedule and cost performance at $Time_{Now}$ may force the program manager to take tasks out of the project (bring the scope of the total project down) in order to complete the program within a firm BAC.
- Program status at completion can be projected. The CPI can be employed to develop a revised estimate on cost to complete the program. Note from equation 3 the CPI is the ratio of BCWP to ACWP. Assume this value is .90. This means that for every dollar spent, only 90 percent of the programmed work for that dollar is actually getting accomplished. If we assume the CPI to date is indicative of future performance (that is, that the CPI will remain reasonably stable for the duration of the project), then we can use the following equation for an estimate at completion (EAC) calculation:

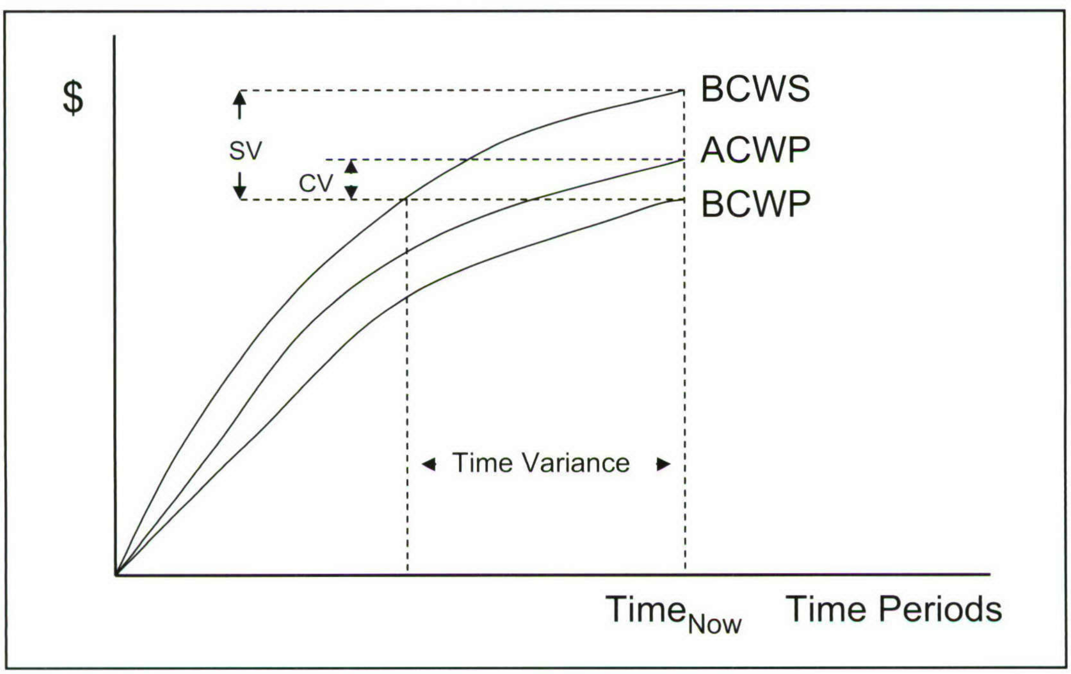

Figure 4. Performance Assessment with EVM Metrics

5. EAC = BAC/CPI

In logic, this equation reduces to the simple proposition that if actual costs are running 11.1 percent ahead of budget for work to date (1.0 divided by .90), a reasonable EAC will likely be 11.1 percent greater than the BAC.

With regard to schedule performance, the SPI given in equation 4 divides BCWP by BCWS. Assume this value is .85. For every dollar of budget (BCWS) only 85 cents worth of work gets completed (BCWP). The inverse of the SPI (BCWS/BCWP) in this example (1.176) would indicate this project is running 17.6 percent behind schedule or that the project is forecasted to take 17.6 percent longer than the original schedule.

These illustrations represent the common employment of EVM to assess the cost and schedule performance of a project. However, rote employment of these metrics is risky and can represent a misuse of EVM—misuse in the sense that these metrics must not be employed in a vacuum or to the exclusion of other performance indicators.

First, consider cost performance metrics. The EAC of equation 5 assumes the remaining work will have the same relative cost variance as work already done.[4] Analysis of root causes or of specific CAPS may show that past performance is not a good predictor of future performance—that a particular problem will not occur again.[5]

Furthermore, if the project is behind schedule, project duration increases and so will costs. Efforts to get the project back on schedule usually mean the employment of more resources (overtime, for example). In short, to project costs without incorporating the cost implications of a schedule variance is a misuse of EVM metrics as well.[6]

The most significant misuse of EVM, however, is in the area of schedule assessment. Using SV as the only measure of schedule performance can lead to erroneous conclusions. For example, some tasks may be performed out of sequence. High-dollar activities may be done ahead of schedule while lesser value critical activities are hopelessly behind schedule. Yet, EVM will show a favorable SV at the project level. A project in aggregate may be ahead of schedule, yet one critical component may not be available. In this situation, heads-up managers know delivery schedules will slip, yet EVM will show this program ahead of schedule.[7]

A quirk of EVM is the fact that every project (even a project behind schedule) shows an SV metric of zero at project completion. This happens because as the project approaches 100 percent completion, the work performed (BCWP) converges on the work scheduled (BCWS)—no more variance. Obviously, at some point prior, the SV as a performance metric has lost its management value.

Clearly, program managers need a schedule management system that is sequence- and milestone-based. EVM may be an aggregate indicator of work performed compared to work scheduled, but to engage EVM as a reliable schedule indicator is a misuse of the tool.[8]

Conclusion

Over the years, a number of significant management innovations and tools with broad application have emerged from the DoD. These include incentive contracting, Performance Evaluation and Review Technique (PERT), configuration management, integrated logistics support, life-cycle costing, and many others. One major tool developed by DoD that continues to face limited familiarity within the logistics community is EVM.

A basic understanding of EVM is important to the logistician, not only because of its intrinsic value to the management of any complex project, but because it is now widely employed in the procurement-program management community of which logistics is a part.

EVM is able to provide a true picture of a project's cost performance by accounting for differences between work accomplished and work scheduled. A number of metrics are employed for variance calculations, performance indices, and projections at completion.

Originally developed as a financial management tool, EVM has become a project management tool for cost, schedule, and scope management. However, this broader approach to EVM generates potential for misuse when the schedule metrics of EVM are used to the exclusion of true schedule management tools. In addition, EAC calculations with EVM metrics should be employed judiciously lest misleading projections arise given the circumstances of any particular project.

This article equips the logistician with an understanding of the terminology and technique of EVM, and provides an appreciation for its uses and potential misuses.

Notes

1. EVM is now an integral part of DoD's guidelines on PBL. See *Performance Based Logistics: A Program Manager's Product Support Guide*, Defense Acquisition University, March 2005, [Online] Available: http://www.dau.mil/pubs/misc/PBL_Guide.pdf, accessed 28 April 2008.
2. The best opportunities for [EVM] may well lie in the management of thousands of smaller projects that are being directed by people who may well be unaware of earned value. Quentin W. Fleming and Joel M. Koppelman, "Earned Value Project Management: A Powerful Tool for Software Projects," *Crosstalk: The Journal of Defense Software Engineering*, July 1998, 23, [Online] Available: http://www.stsc.hill.af.mil/crosstalk/1998/07/value.asp, accessed 11 November 2007.
3. The 32 standards have evolved into an American National Standards Institute (ANSI) standard on *Earned Value Management System Guidelines*, ANSI/EIA-748-A-1998 (R2002). Copies can be ordered from Global Engineering Documents (800-854-7179). DoD policy and guidance on EVM are online and available at www.acq.osd.mil/pm.
4. For a complete assessment of this issue, see David Christensen and Kirk Payne, "Cost Performance Index Stability—Fact or Fiction?" *Journal of Parametrics*, 10 April 1992, 27-40, and David S. Christensen, "Using Performance Indices to Evaluate the Estimate at Completion," *Journal of Cost Analysis and Management*, Spring 1994, 17-24.
5. Different shops, different work forces, different subcontractors, and different cost problems within a project don't necessarily invite a mirrored projection of past performance into the future. And cost variances in production don't necessarily mean similar variances in assembly.
6. Jan Evensmo and Jan Terje Karlsen, "Reviewing the Assumptions Behind Performance Indexes," *Transactions of AACE International CSC 14*, 2004, 1-7.
7. See Jim W. Short, Using Schedule Variance as the Only Measure of Schedule Performance, *Cost Engineering*, Vol 35, No 10, October 1993, 35. Also see Walter H. Lipke, "Schedule is Different," *The Measurable News*, Summer 2003, 31-34.
8. Seasoned practitioners of EVM are increasingly realizing that EVM is considerably more useful as a tool for measuring and managing cost performance than it is for schedule performance. Indeed, the earned value concept was developed to get appropriate data for cost assessment. The dollarized schedule assessment is a byproduct fraught with difficulties. In this sense, EVM better serves project managers as a *financial management* tool rather than a cost-schedule-scope *project management* tool.

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If I had to sum up in a word what makes a good manager, I'd say decisiveness. You can use the fanciest computers to gather the numbers, but in the end you have to set a timetable and act.

—Lido Anthony (Lee) Iacocca

If opportunity doesn't knock, build a door.

—Milton Berle

No form of transportation ever really dies out. Every new form is an addition to, and not a substitution for, an old form of transportation.

—Air Marshal Viscount Hugh M. Trenchard, RAF

EXPLORING THE HEART OF LOGISTICS

User Perceptions of Intransit Visibility Architecture Utility

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Background

During the buildup of Operation Desert Shield, the Saudi Arabian ports of Ad Dammam and Al Jubayl were congested with tens of thousands of military and commercially leased containers.[1] The containers were required to transport the vast amount of equipment to the region in preparation for the liberation of Kuwait. The problem, in essence, was threefold:

- Delivering the containers to the various ports
- Knowing what was in the containers
- Knowing who owned them once they arrived

Of the 40,000 containers in the port, 25,000 required opening to determine the owner and their contents, carrying an associated price tag of $1B.[2] According to the former director of logistics for United States Transportation Command, General Walter Kross,

> During the Gulf War, we simply did not have good information on almost anything. We did not have good tracking; we had no real asset visibility. Materiel would enter the logistics pipeline based on murky requirements, and then it could not really be tracked ... when it got to the other end we had to deal with the consequences ... we lacked the necessary priority flows to understand where and when things were moving.[3]

The consequence that had to then be dealt with was the possibility of delayed missions resulting from not knowing the whereabouts of essential organizational equipment. This issue, along with many other supply chain issues, was collected and analyzed in the years following Desert Storm, yet some of the same issues with equipment and container management found their way into Operation Iraqi Freedom (OIF). These continuing logistical challenges forced the Army to revamp its distribution management process for tracking commodities and equipment. Commanders needed more accurate information, they needed it faster, and they needed the information in as near real time as possible. The previous methods of military shipping labels, bar codes, and radio frequency identification tags (RFID) were not providing the data commanders needed to conduct their missions. This was the case at the beginning of OIF prior to the Army's logistics transformation.

The Army's logistics transformation began with the development of the Unit of Employment (UE) concept. The UE concept redesigned and redistributed support units to support mission sets and made modular deployment easier (deployment of preconfigured and predetermined combat and support assets).[4] Existing logistical support and management organizations were combined in an effort to reduce staff levels and reduce redundancy in the distribution process. As retired Lieutenant Colonel James Henderson, deputy commander for the 13[th] Corps Support Command Corps Distribution Command, states in his book, *The Process of Military Distribution Management,* "In order for the Army's Logistics Transformation to be able to improve the timely and accurate distribution of supplies, logisticians must incorporate proper velocity management techniques."[5]

A key velocity management technique is intransit visibility (ITV).

Article Acronyms

AIT – Automatic Identification Technology
BCS3 – Battle Command Sustainment and Support system
DoD – Department of Defense
EIS – Enterprise Information System
GAO – Government Accountability Office
GCCS – Global Command and Control System
GTN – Global Transportation Network
ITV – Intransit Visibility
KMO – Kaiser-Meyer-Olkin
MSL – Military Shipping Label
MTS – Movement Tracking System
OIF – Operation Iraqi Freedom
PEO – Program Executive Officer
POC – Point of Contact
RFID – Remote Frequency Identification
RQ – Research Question
SME – Subject Matter Expert
TAV – Total Asset Visibility
TIS – Transportation Information Systems
UE – Unit of Employment

To support the logistics transformation effort, the Army uses intransit visibility. ITV is an automated capability designed to improve the ability of commanders and personnel to obtain real-time information on the location, quantity, and movement of equipment through the logistics pipeline.[6] ITV should not be confused with total asset visibility (TAV). TAV reports the status of production, commodity inventory, repair status, requisition, and stockage levels. ITV is the tracking of assets as they pass through a node or while enroute. However, TAV is dependent upon ITV. As Lieutenant Colonel Beth Rowley, Joint-Automated Identification Technology Program Manager stated, "ITV is not a single system, but rather a collection of automatic information systems, procedures, systems interfaces, and application technologies."[7]

In December 2003, the Government Accountability Office (GAO) released a preliminary report on the observations and effectiveness of logistic activities during OIF.[8] The report stated the problem with ITV was Army logisticians could not see all the requirements on the battlefield, and the customers (supported units) could not see the supplies coming their way. The inability to track supplies encouraged soldiers and commanders to order the same item several times because they had no confidence that support was enroute. Current attempts to solve these dilemmas consist of Web-based, data-integrated ITV components that feed into 21 Department of Defense (DoD) logistics systems. These 21 DoD ITV systems provide data to track commodities at their last known location (nodal tracking), and to see in near real time the physical location of the equipment or commodity enroute. A portion of the 21 DoD ITV systems provide real-time asset visibility which allows commanders to see the current location of their assets and gives them the ability to divert the assets while enroute. However, which of the 21 DoD ITV systems does the commander and his or her staff use? Which system does the commander's customer use? If the ITV system the organizations will use while deployed varies from the system or systems used in garrison, will the organizations be able to educate themselves on a new system in a timely manner in order to reap the benefits of the unfamiliar system? It is apparent there are still too many choices for military organizations when it comes to ITV. This observation is prevalent in a majority of the papers written on ITV. Lieutenant Colonel Nicholas J. Anderson observes that the multitude of ITV systems available makes it difficult to provide systematic training at any of the combat service support schools.[9]

Purpose

There are multiple ITV systems available for DoD personnel to use. Authorized personnel have access to the Global Transportation Network (GTN), Battle Command Sustainment and Support System (BCS3), Global Command and Control System (GCCS), and the ITV Network Server to name a few. However, which system is the best? The answer to this question depends, to a degree, upon whom you ask. Currently, the four systems previously identified were the most widely used during OIF and Operation Enduring Freedom, but duty location and level of command will determine the system used. By providing a single ITV platform for use in garrison and combat, users will experience a more fluid transition and possibly a better knowledge base of ITV.

Research Questions

The following research questions (RQ) will be addressed.

- RQ 1: How successful do commanders and users perceive the current ITV architecture in terms of its utility and tracking capability?
- RQ 2 (A): Is there a relationship between a user's knowledge of ITV in general and ITV reducing duplicate commodity ordering?
- RQ 2 (B): Is there a relationship between a user's knowledge of ITV in general and its ability to provide the data required to do his or her job?
- RQ 3 (A): Is there a relationship between the user's knowledge of individual ITV systems and the system's ability to reduce duplicate orders?
- RQ3 (B); Is there a relationship between the user's knowledge of specific ITV systems and its ability to provide the data required to do his or her job?

Data were specifically collected and analyzed from an Army ITV perspective. Weber stated that data from a familiar branch of Service is more easily interpreted than data from other Services.[10] In his research of turnover in military organizations, Bluedorn used data that was specific to his Service branch, the US Army.[11] Therefore, the data used for this research is Army-centric, based on one author's familiarity with the Army and its ITV systems and architecture.

In order to understand ITV, an explanation of the types of automatic identification technology (AIT) with respect to ITV's primary goal and how ITV contributes to total asset visibility is required. ITV is fed by multiple AIT sources. The DoD uses many types of AIT, to include barcodes, RFID, and the Movement Tracking System (MTS).

Barcodes provide item identification for individual items and shipments by document number. Military shipping labels (MSL) and barcodes are used when individual items are consolidated into a larger container. The MSLs and barcodes can be read using a hand-held interrogator or portable data terminal. The data can then be loaded into the RFID tag and attached to the individual piece of equipment or to its shipping container or pallet. The second component of the RFID tag is the interrogator. The interrogator can be either fixed or handheld and reads the coded data within the RFID tag and reports the date and time the RFID tag passed by the interrogator. To ensure positive control, interrogators are normally set up in locations where commodities and equipment change hands. For example, to track equipment movement, interrogators are set up at the ingress and egress of vehicle marshalling yards, warehouses, as well as air and seaports.

Within ITV, the real-time movement of commodities and equipment is tracked using the MTS. MTS provides an operational link to assets sent out on missions to maintain command discipline. MTS is a satellite tracking and text message system that provides command and control over distribution assets. One central host that fuses data from RFID tags and MTS is called the BCS3. BCS3 is an *end-to-end* cargo and equipment tracking management system. Operators can constantly monitor movement of assets via terminal servers that can be loaded on most laptop computers. This conglomeration of automatic

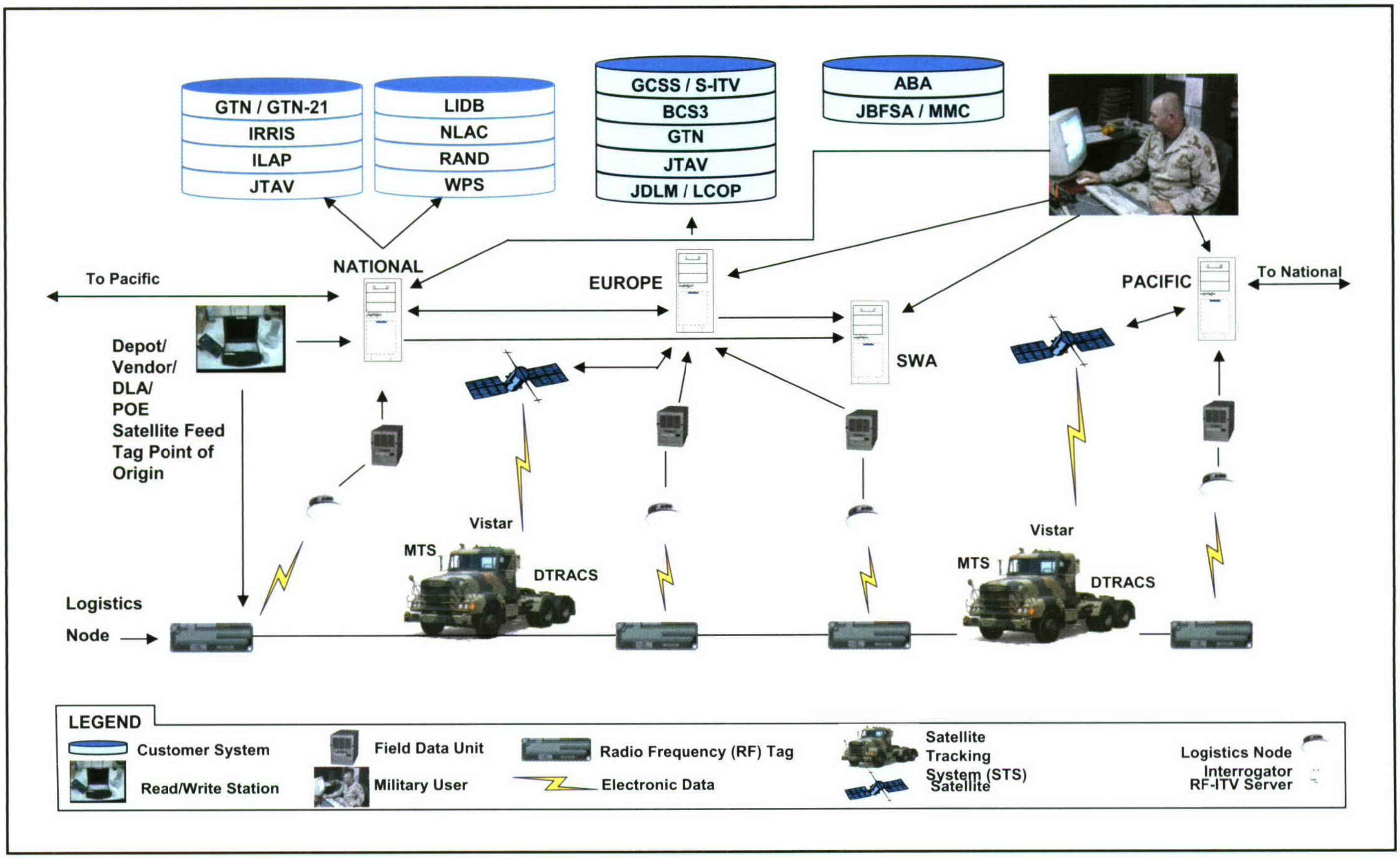

Figure 1. RF-ITV Operational View

information systems provides the framework for the ITV architecture. Other systems that provide end-to-end tracking capabilities are the GTN, GCCS, and the ITV Network Server. Refer to Figure 1 for an operational view of ITV and the various user interface systems.

Procedures

Since existing measures were not available to address the research questions, measures were created based on interviews with ITV subject matter experts (SME) to include program managers. SMEs were questioned as to the types of data ITV should provide the user. The same SMEs were asked what information would help determine if a specific ITV system was outperforming all others and if this information could benefit planners and program managers with developing a single ITV user interface. In addition, SMEs stated that ITV should give the user confidence in the distribution process and that having the ability to track an order from the time it is pulled from the shelf to the time the consignee takes possession should provide the user that confidence.

A 55-item survey entitled, *Commander and User Perceptions of the Army's ITV Architecture*, was developed, pilot tested, and then disseminated via Web-link to transportation organizations that, for the most part, had some familiarity with the functionality and use of ITV systems. The survey Web-link was sent to respondent points of contact (POC) which included two transportation battalion commanders located outside the continental United States and program managers of various ITV departments at the US Army Combined Arms Support Command. Respondent POCs received advanced notification of the online survey in the form of an e-mail that indicated the survey's intent and to solidify participation in the research. Respondents were then contacted via e-mail from the respondent POCs. Respondent POCs asked the respondents to complete the online survey and answer the questions in a way that best described their feelings on a specific ITV system. Respondents were requested to complete the survey within a 3-week timeframe. At the end of 3 weeks, a followup e-mail was sent to the respondent POCs requesting they send a reminder to their respondents.

To increase the sample size, the researcher conducted a second administration of the survey at the Army Logistics Management College at Fort Lee, Virginia, to the students enrolled in the Combined Logistics Captains Career Course and the Logistics Executive Development Course. The response rate from this administration of the survey was 95 percent.

Participants

For both administrations, the survey population (n = 213) included members of the US Army, Air Force, Marines, Navy, and civilian DoD personnel. A total of 124 surveys were usable (38 online and 86 hardcopy, respectively). Of the 169 respondents returning the hard copy survey, 42 indicated they had not used any ITV system, 22 indicated they used multiple systems (thus eliminating analysis on their knowledge of a specific system), and 19 surveys had a majority of the data missing, resulting in 86 respondents that provided usable data for analysis. Data from the hard copy surveys were coded by the researcher. After completion of every 10 survey entries, the researcher verified each entry to ensure accuracy.

In terms of sample demographics, 46 respondents (37 percent) indicated they were either in a command billet or had previously commanded, and 61 respondents (49 percent) had no command

experience. Seventy-four respondents (60 percent) answered the survey in terms of their personal training and experience of the ITV systems, 8 personnel (6 percent) answered with regards to personnel under their supervision on training and experience, and 26 respondents (21 percent) answered the survey in terms of both their training and experience, and that of their subordinates. Refer to Table 1 for information pertaining to respondent rank, time in service, and deployments over the last 4 years.

Measures

The survey was comprised of 55 items, including the following:

- Fourteen questions were asked in the first part of the survey to assess satisfaction with a particular ITV system
- Five items were used to evaluate supply ordering habits and daily ITV usage
- Nine items addressed the user's familiarity with all ITV systems
- Sixteen items were used to evaluate training on the ITV systems
- Eleven items were used to determine demographic information

Factor Structure and Reliability Estimates

A factor analysis was used to determine the underlying factor structure of the 14 survey items in Part 1. Preliminary analysis indicated the data were appropriate for factor analysis. The analysis included:

- Inter-item correlation matrix
- Off-diagonal of the anti-image covariance matrix
- Bartlett's Test of Sphericity
- Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy

The inter-item correlation matrix should result in a positive relationship between each of the items. Items with a correlation at or above .90 were analyzed to ensure the items were not measuring the same factor.[12] Small values on the off-diagonal and anti-imaging matrix further indicate the data are a good fit for factor analysis. The Bartlett's Test of Sphericity indicated the correlation matrix was an identity matrix as well (significant at $p < .001$), and all diagonal terms had a value of 1 while off-diagonal terms were 0. The KMO measure of sampling adequacy reflects the homogeneity among the variables and serves as an index for comparing the magnitudes of correlation coefficients to partial correlation coefficients. KMO values at or exceeding .70 are considered desirable (KMO = .92).[13]

The survey was analyzed using the Component Factor model, Principal Axis Factoring. Several methods are available when deciding the number of factors to retain, to include eigenvalues and scree plots. However, using only one method may result in the use of too many or too few factors. As Conway and Huffcutt recommended, methods used in conjunction with one another provide a stronger argument for factor retention and deletion.[14] Therefore, factors with eigenvalues greater than 1 and scree plots were used to determine the factor structure. The eigenvalue results produced a 2-factor solution that explained 67 percent of the total variance.

Normally, items loading on factors with a value greater than or equal to .30 are utilized.[15] Once factor loadings were determined, inter-item correlations and Cronbach Alpha Coefficients were measured in order to determine the internal consistency of the factors. According to Nunnally, factor structures are satisfactory with an alpha value greater than or equal to .70.[16] The factor analysis process resulted in the extraction of 2 factors: Factor 1 named *utility*, and Factor 2 named *tracking*. Refer to Table 2 for utility and tracking factor loadings, reliabilities, and means.

The most common ITV systems were listed in section 2 of the survey. Using a scale anchored by 1 (not at all) and 5 (to a very large extent), respondents were asked to categorize their knowledge of the following systems: BCS3, GTN, GCCS, RFID, Deployed Asset Visibility System, ITV Network Server, other, none, and ITV in general.

Section 3 involved training received by the respondent or by the subordinates of the respondent. Using a scale anchored by 1 (strongly disagree) and 6 (agree), respondents were asked how sufficient was the training received. Respondents also provided demographic information, to include military occupation code or branch, total time deployed, location of deployment, DoD status, branch of Service, time in grade, highest level of education, and command status.

Descriptive Information

In all, the survey had 124 respondents. The predominant ITV system was the BCS3 (n=42), followed by GTN (n=23); GCCS – Army (n=8); the ITV Network Server (n=22); *other* (n=20), which

Rank	N	Percentage	Avg Time in Service*	Avg Number of Deployments over Last 4 Years
First Lt (O2)	7	6	13**	2
Captain (O3)	64	52	9	3
Major (O4)	18	15	16	2
Lt Colonel (O5)	9	8	21	2
Chief Warrant 4	1	<1	30	3
Specialist (E4)	1	<1	4	no data
Sergeant (E5)	4	3	6	2
Staff Sergeant (E6)	1	<1	14	1
Sergeant First Class (E7)	1	<1	14	1
DoD Civilian	7	6	16	1
DoD Contractor	3	2	29	no data
No Data	7	7	na	
	123	99***		
*In Years				
**High avg. due to Reserve Soldiers				
***Does not equal 100 due to rounding				

Table 1. Demographics by Rank, Time-in-Service, and Average Number of Deployments

Factor / Item	Item Nomenclature	Factor Loading
Factor 1	ITV Utility = .94, n = 103, M = 4.9, SD = 1.2	
Item 1	I feel the ITV system I am currently using is easy to use.	.601
Item 4	I feel the ITV system I am currently using produces the data I need to do my job.	.811
Item 5	I feel the ITV system I am currently using provides enough data for me to make decisions.	.895
Item 6	I feel the ITV system I am currently using gives me a greater ability to plan.	.854
Item 8	I feel the ITV system I am currently using provides me the ability to track my equipment and supplies while en route.	.813
Item 10	I feel the ITV system I am currently using allows me to do my job more efficiently than other ITV methods.	.741
Item 11	I feel the ITV system I am currently using increases my confidence in supply chain management.	.817
Item 12	As a result of the ITV system I am currently using, I can better predict when supplies will arrive.	.814
Item 14	I feel the ITV system I am currently using enhances my ability to plan in support of my current mission.	.874
Factor 2	ITV Tracking Ability = .82, n = 103, M = 4.4, SD = 1.1	
Item 2	I feel the ITV system I am currently using reduces wait time when ordering CL II and CL IX.	.674
Item 3	I feel the ITV system I am currently using has limited duplicate ordering.	.662
Item 7	I feel the ability to track equipment and/or supplies while en route gives me more confidence in the distribution chain.	.554
Item 9	I feel the ITV system I am currently using gives me the opportunity to fix misdirected shipments.	.787
Item 13	The improved usability of my current ITV system reduces the amount of spare parts I order.	.762

Table 2. Factor Loadings and Reliability Estimates

included systems such as MTS, Blue Force Tracker, and Logistics Information Warehouse (LIW).

Research Question One

The first research question (RQ1) involved sorting the respondents based on the most current ITV system they used. The four primary ITV systems; BCS3, GTN, ITV Network Server, and GCCS were in individual categories while the remainder of the ITV systems were grouped into other ITV Systems. Independent sample t-tests were used to address this question. Specifically, the users' mean scores on utility and tracking were calculated by ITV system. The users' mean score for all ITV systems were then compared to determine if a specific system was identified more frequently than other systems. Refer to Table 3 for independent sample t-tests for the results.

Comparing the means of the individual ITV systems and the factors, utility and tracking, only two system comparisons, GCCS and ITV Network Server, produced significant mean differences indicating a difference in the perception of utility and tracking between GCCS and ITV Network Server exists such that respondents preferred ITV Network Server to GCCS (t=-2.7, p<.01). It is noteworthy that the GCCS users are all field grade officers with experience at echelons above corps staff, suggesting GCCS may have more of an operational function for the users versus a tactical function like that of the ITV Network Server.

Though the independent sample t-test comparison only produced one statistically significant result, there were consistent trends in the mean scores of the ITV systems. The ITV Network Server had a larger mean score for both utility (M = 5.3) and tracking (M = 4.9), indicating that users slightly agree that ITV Network Server provides better utility and tracking over the other ITV systems tested. Refer to Table 3 for ITV Network Server mean score.

Research Question Two

Research question 2 (RQ2) was considered in two parts. The first part of RQ2 (A) was addressed via bivariate correlations between mean scores in an effort to determine significant relationships between user knowledge of ITV in general, and ITV's ability to reduce duplicate commodity ordering. The second part of RQ2 (B) was also analyzed via bivariate correlations between mean scores to assess the relationship between user knowledge of ITV in general, and its ability to provide the data commanders and users need to do their jobs. Results of the relationships between user knowledge of ITV in general, and the relationship between its ability to reduce duplicate commodity orders and provide data required for the user to do his or her job are provided in Table 4.

Correlational analysis results indicated no significant relationship between ITV use and the perception that ITV use limited duplicate commodity orders (r=.15). However, ITV in general does appear to provide users and commanders the information needed to do their job (r=.25, p<.01).

Research Question Three

Research question 3 (RQ3) was considered in two parts. The first part of RQ3 (A) sought to determine whether a relationship existed between user knowledge of an individual ITV system, to include RFID, and the system's ability to reduce duplicate orders. The second part of RQ3 (B) sought to determine whether a relationship existed between user knowledge of an individual ITV system and its ability to provide the user the data needed to do his or her job. Results of individual ITV systems abilities to reduce duplicate ordering and providing users with the data required to do their jobs are presented in Table 5.

Correlational analysis results for the first part of RQ3 (A) indicated no significant relationship between a specific ITV system and the perception that the use of an individual ITV system limited duplicate commodity orders. Thus, the perception was that individual ITV systems did not appear to reduce duplicate commodity ordering.

For the second part of RQ3 (B), results supported user perceptions that the use of RFID and the ITV Network Server provides the user with the information and data needed to do his

	FACTOR 1 - UTILITY						FACTOR 2 - TRACKING			
	N	M	t	sig.			N	M	t	sig.
BCS3	38	4.8	.03	0.97		BCS3	38	4.5	1.2	.23
GTN	21	4.7				GTN	19	4.1		
BCS3	38	4.8	-2	0.06		BCS3	38	4.5	-1.5	.14
ITV NETWORK SERVER	20	5.3				ITV NETWORK SERVER	20	4.9		
BCS3	38	4.8	1.3	.2		BCS3	38	4.5	1.7	.1
GCCS	9	4.1				GCCS	9	3.9		
BCS3	38	4.8	-1.1	.27		BCS3	38	4.5	-.47	.64
OTHER ITV SYSTEMS	18	5.1				OTHER ITV SYSTEMS	20	4.6		
GTN	21	4.7	-1.8	.08		GTN	19	4.1	-2	.06
ITV NETWORK SERVER	20	5.3				ITV NETWORK SERVER	20	4.9		
GTN	21	4.7	1.1	.27		GTN	19	4.1	.41	.68
GCCS	9	4.1				GCCS	9	3.9		
GTN	21	4.7	-1	.31		GTN	19	4.1	-1.3	.2
OTHER ITV SYSTEMS	18	5.1				OTHER ITV SYSTEMS	20	4.6		
GCCS	9	4.1	-2.7	(.01*)[1]		GCCS	9	3.9	-2.3	(.03*)[1]
ITV NETWORK SERVER	20	5.3				ITV NETWORK SERVER	20	4.9		
GCCS	9	4.1	-2	.06		GCCS	9	3.9	-1.8	.09
OTHER ITV SYSTEMS	18	5.1				OTHER ITV SYSTEMS	20	4.6		
ITV NETWORK SERVER	20	5.3	.8	.43		ITV NETWORK SERVER	20	4.9	.86	.37
OTHER ITV SYSTEMS	18	5.1				OTHER ITV SYSTEMS	20	4.6		
[1] Research Question 1 *Results significant between .05 and ,001 (2 - tailed)						*Results significant between .05 and ,001 (2 - tailed)				

Table 3. Independent Sample T-Tests Factor Comparison of ITV Systems

or her job ($r = .21$, $p<.05$ and $r=.32$, $p<.01$, respectively). Refer to Table 5 for RFID and ITV Network Server results.

Summary

Research Question 1 results indicated respondents preferred GCCS and ITV Network Server for both utility and tracking. This may be due, in part, to the fact that more users have access to the ITV Network System. Since GCCS must be accessed via secure communication, requiring a minimum secret clearance, not all users have the security clearances required to access GCCS. GCCS as an ITV tool, may be more beneficial for commanders and higher echelons of strategic and operational staffs because of its ability to provide secure messaging, tracking, and intelligence for planners and commanders. On the other hand,

Item	1	2	3
1	1		
	(n=106)		
2	.15	1	
	(n=103)	(n=112)	
3	.25*	.38**	1
	(n=105)	(n=111)	(n=114)

Table 4. Correlations for ITV Knowledge, Duplicate Order Reduction, and Data (Note: *p<.05 [2-tailed]; **p<.01 [2-tailed]; 1 User's overall knowledge of ITV in general; 2 ITV limits duplicate ordering; 3 ITV produces the data I needed to do the job)

Item	BSC3	GTN	GCCS	RFID	ITV Network Server	Other ITV	3	4
BSC3	1							
	(n=113)							
GTN	.14	1						
	(n=110)	(n=112)						
GCCS	.02	.29**	1					
	(n=110)	(n=112)	(n=112)					
RFID	.21*	.52**	.22*	1				
	(n=108)	(n=110)	(n=110)	(n=110)				
ITV Network Server	.31**	.35**	.05	.68**	1			
	(n=109)	(n=109)	(n=109)	(n=107)	(n=109)			
Other ITV	-.03	.03	.05	.28(*)	.10	1		
	(n=78)	(n=78)	(n=78)	(n=78)	(n=76)	(n=79)		
3	.12	-.07	-.07	.04	.15	-.16	1	
	(n=110)	(n=109)	(n=109)	(n=107)	(n=106)	(n=77)	(n=112)	
4	.17	.13	-.06	.21(*)[1]	.32(**)[1]	.20	.38(**)	1
	(n=112)	(n=111)	(n=111)	(n=109)	(n=108)	(n=78)	(n=111)	(n=114)
*Correlation is significant at the 0.05 level (2-tailed).								
**Correlation is significant at the 0.01 level (2-tailed).								
3. ITV limits duplicate ordering								
4. ITV produces the data I need to do my job. [1]Answers RQ3(B)								

Table 5. Correlations Between ITV Systems, Duplicate Order Reduction, and Data

the ITV Network System may have greater benefit for users since a majority of the users are mainly concerned with tracking the status of equipment and commodities at the tactical level.

Surprisingly, users did not perceive ITV use in general or any specific ITV system as a tool to limit duplicate ordering. Based on RQ 2 (A) and RQ 3 (A) analysis, 65 respondents indicated they continued to duplicate commodity orders for fear of not getting what they need. As all 65 of the respondents used an ITV system to track visibility of their equipment and commodities, results suggest users still do not see ITV as a tool of confidence when it comes to supply chain management.

Study Limitations

The primary study limitation involved the representativeness of the sample. Expanding the survey field to include other US Army educational programs, to include the Combined General Staff College and the US Army War College, might result in increasing the respondents in command positions. Responses from a larger command population would show how ITV has benefited, or fallen short of benefiting users from a commander perspective. The commanders could also provide feedback on what initiatives could be taken to improve the information from ITV systems. By addressing a larger command population, commanders could express to the program managers ideas or desires that would help provide information or data from the ITV systems that would, for example, limit duplicate ordering. For example, if an ITV system could produce military shipping labels, organize equipment, and produce organizational equipment lists, then transportation information systems (TIS) such as Transportation Coordinator Automated Command and Control Information System and the transportation Coordinator's Automated Information for Movement System, Version II could be streamlined. Since at most installations, TIS are aggregated at a central location and not as readily available as most of the ITV systems, users could update and manage equipment densities with less difficulty.

Implications for Future Research

Possible future research could be conducted to assess the relationship between the training location, type of training, and length of training to focus resources, training time, and attention in order to better train personnel on the ITV systems currently used.

Additional research could be conducted on the individual ITV systems presented in this study. Researchers could focus on a

specific system and conduct controlled experiments with the users of the respective systems. This type of research could provide more detailed data for program managers responsible for ITV implementation. Program managers could further this study to analyze all costs associated with training for multiple systems in an effort to determine if monetary savings exist with a single system.

A 2006 article from the Program Executive Office, Enterprise Information Systems (PEO EIS) referenced the impact of RF-ITV on areas such as customer wait time and duplicate requests.[17] In the 8 months following the inclusion of RFID within tactical business process, the Marine Corps was able to reduce their customer wait time from 28 to 16 days. The monetary result was a reduction in $47M of inventory and a retrograde savings of $17M.[17] This indeed is one of the intents of ITV. However, what type of study was conducted that produced these results? Were there factors other than ITV that influenced the reduction in inventory, such as reduced storage facilities? A future effort could involve incorporating Marine Corps study metrics with this research effort and be expanded to include all ITV systems to assess whether similar results could be obtained. In addition, further research could evaluate which ITV systems users perceive to reduce customer wait time.

Conclusion

The overall purpose of this research was to determine if there was a specific ITV system users preferred. Although there were no significant differences between the individual systems, a recurring theme was observed from the respondents—there are too many systems. There should be one system used in garrison that we can take and also use while deployed. This leads to the question of whether one ITV system can replicate the capabilities of all other ITV systems as a single interface for commanders and users? By analyzing the expectations and requirements of the ITV system, program officials may be able to ascertain whether a single system is viable.

Another common theme noted was that respondents indicated ITV is seldom used while in garrison to monitor the flow of commodities in the supply chain. This may have some influence on why there were no significant relationships between ITV use and limiting duplicate commodity orders. If commanders and users use the same ITV system when deployed as used in garrison, they may develop more confidence in the distribution process. Increased emphasis on in-garrison training and use of the ITV systems could increase commander and user confidence in the distribution process.

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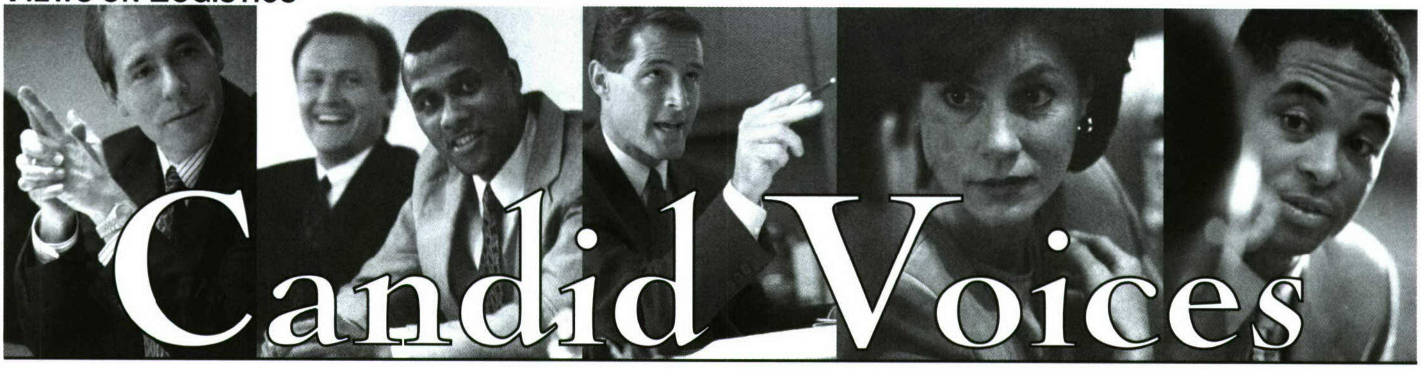
...instant history [was] invariably shallow history.

—Anthony Cordesman



BRAC Change Management at DLA: A Collaborative Effort with the Services

Kimberly Austin, DLA

BRAC Change Management at DLA: A Collaborative Effort with the Services

The 2005 Base Realignment and Closure (BRAC) legislation included three supply and storage decisions. The Defense Logistics Agency (DLA) was designated as the Department of Defense (DoD) business manager for these three decisions with the responsibility of coordinating with the military Services to implement:

- **Commodity Management Privatization**. Creates long-term contracts satisfying all supply, storage, and distribution requirements for tires, packaged petroleum, oil, lubricant products, and compressed gases and cylinders. This includes transferring vendor supply contracting functions for these products from the military Services to DLA.
- **Depot-Level Reparable (DLR) Procurement Management Consolidation (includes consumable item transfer).** Realigns procurement management and related support functions for the procurement of new DLRs from the military Services to DLA, thus creating a single, integrated DoD buying organization for new DLRs. This decision also further consolidates consumable item management by transferring work related to the management of remaining service consumable items (with some exceptions) from the military Services to DLA.
- **Supply, Storage, and Distribution (SS&D) Management Reconfiguration.** Consolidates the supply, storage, and distribution functions and associated inventories at the current DLA depots with the military Services' maintenance activities to support operations, maintenance, and production.

Article Acronyms

BRAC – Base Realignment and Closure
BSM – Business Systems Modernization
CRM – Customer Relations Management
DLA – Defense Logistics Agency
DLR – Depot Level Reparable
DoD – Department of Defense
EBS – Enterprise Business System
SS&D – Supply, Storage, and Distribution

These BRAC decisions are transforming DLA. With BRAC 2005, DLA is taking on new missions previously performed by the military Services. In addition to the transfer of functions to DLA, military personnel with a wealth of experience and knowledge in consumer-level logistics are transferring to DLA to support these missions. As of August 2008, almost 1,100 employees from the Air Force and the Navy have become DLA employees, with additional Air Force, Navy, Army, and Marine Corps personnel set to join the DLA workforce in the coming months and years.

This transfer of missions directs DLA to operate well beyond its traditional wholesale boundaries. It requires the people who are in DLA's existing workforce to shift their mindset from traditional wholesale supply excellence to the broader end-to-end supply chain excellence.

With the magnitude and breadth of these BRAC changes it was clear from the outset that an organized approach to BRAC change management for all stakeholders would be critical for successful transformation. While the stage had been set with previous change management efforts applied to prior DLA initiatives, BRAC has brought about some unique and significant challenges.

The History of Change Management at DLA

Formal change management at DLA has its roots in the Business Systems Modernization (BSM) program which launched DLA's enterprise resource planning (ERP) system now known as the Enterprise Business System (EBS). At the outset of BSM, contractor support was used to help roll out many aspects of BSM, including the development of a change management approach. This approach included using a combination of contractors and DLA employees fully dedicated to BSM change management. These employees were not from personnel or public affairs—they were chosen for their subject matter expertise in logistics, their knowledge of the DLA workforce, and their leadership at their particular site.

DLA, while one organization, has unique cultures at each field activity and depot. Deep knowledge of the stakeholders was essential for change management success. Because of this, a headquarters-driven, or a one-size-fits-all approach to implementing change management was unrealistic. Altogether, this effort consisted of approximately 25 dedicated contractor

and government employee team members between 2001 and 2006. As originally planned, most BSM government change management positions were absorbed into the organization upon successful implementation of BSM in 2006. EBS efforts have continued.

After BSM, a formal Customer Relations Management (CRM) program was introduced at DLA. Once again, contractors were asked to develop an approach to change management. Their approach also relied on participation from DLA employees. Because a different contractor was used, there was a different look and feel to these change management efforts. DLA leadership concluded that change management should be an organic capability. DLA would develop the approach to change management with possible assistance from contractors rather than the other way around. Nevertheless, despite the lack of a consistent approach, change management efforts for both BSM and CRM were generally regarded as successful. These two initiatives were the first to address change management in a structured and organized way at DLA. Although the full-time government positions dedicated to change management were redirected, the corporate knowledge stayed, and those DLA employees continue to be heavily involved in all agency change management efforts.

Following the BSM and CRM programs, DLA senior leadership defined change management at DLA as "the intentional and structured application of process, tools, and techniques to manage the people side of a change in order to achieve the desired state."

BRAC Change Management at DLA

With the breadth of impacted stakeholders and the scope and timing of the changes required, DLA faces a significant change management challenge with BRAC 2005. The goal of BRAC change management is threefold:

- Ensure the successful transition of personnel from the Services to DLA with the least amount of disruption to the workforce, while ensuring no degradation of support to the warfighter
- Prepare the DLA workforce for the shift in culture necessary to deliver end-to-end supply chain integration
- Instill confidence in its customers that DLA can handle the new mission as set forth in the 2005 BRAC legislation

Although popular change management models often include training and organizational alignment aspects, these are considered distinct components from BRAC change management efforts at DLA. This decision was made because the scope of training and organizational alignment, as a result of BRAC, was complex enough to warrant separate consideration while acknowledging the need to coordinate and synchronize with change management efforts. Currently, change management at DLA is approached in three work streams: communications, sponsorship, and change readiness.

Partnering with the Military Services to Ensure Success

One thing distinguishing BRAC 2005 from previous change management efforts is the critical partnership with the military Services' change management representatives. These representatives have been identified for each site as well as headquarters components such as Air Force Materiel Command. For the initial transfer of DLR and SS&D employees from the military Services to DLA, it is important to establish two-way communication and sponsorship events with affected employees before their first day as DLA employees. Creating sponsorship opportunities with their current leaders, as well as their future DLA leaders, helps build bridges from the Service organizations to DLA. Additionally, change readiness activities are at the discretion of the Services. Without the work of these knowledgeable Service change management representatives, effective BRAC change management would be impossible. We would have lost the communication battle before it started.

Change management representatives from the military Services help the DLA team understand the culture, fears, and concerns of their workforce. They also interact with their

- **Communications: provides the right information, to the right people, at the right time, to build awareness, understanding, buy-in, and commitment**
- **Sponsorship: builds commitment and support for the change effort with leaders**
- **Change Readiness: assesses and monitors the workforce's readiness for change and provides feedback to Communications and Sponsorship work streams in order to address CM issues**

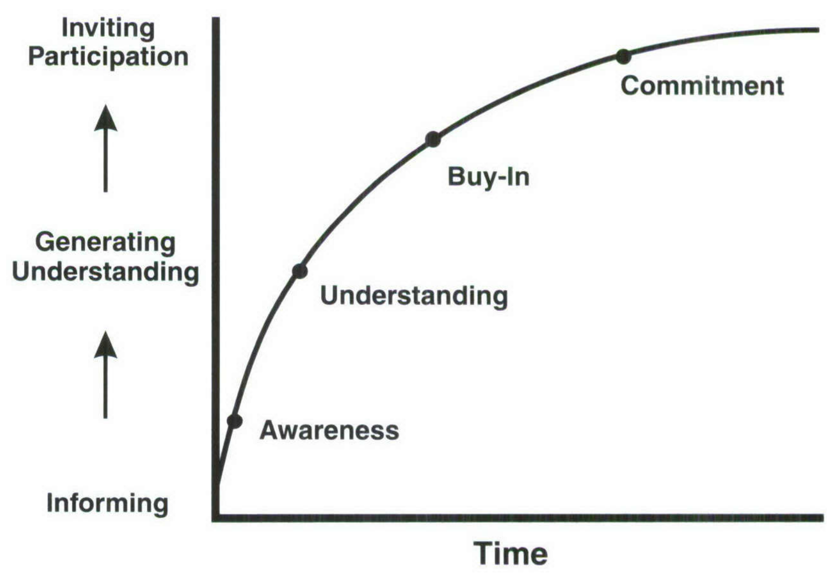


Figure 1. BRAC Change Management Workstreams at DLA

leadership, help design change management activities at individual sites, and take responsibility for implementing many of the change management deliverables. In turn, DLA provides templates and lessons learned from other BRAC sites, manages and monitors program deliverables, hosts teleconferences and face-to-face meetings with change management personnel across the Services, and works with DLA senior leadership to coordinate sponsorship events. Additionally, the DLA change management team provides communication products and vehicles, including brochures, videos, answers to frequently asked questions, employee access to a BRAC Website, and articles. This collaborative effort with the Services is an essential aspect of effectively implementing BRAC legislation and realizing BRAC objectives designed to enhance efficiencies and effectiveness within the DoD supply chain.

BRAC Change Management Challenges

The BRAC legislation states that decisions will be implemented by September 2011; however, achieving savings, efficiencies, and improvements will continue beyond the initial implementation. This extended timeframe creates challenges. Change management representatives from the Services are focused on many other initiatives in addition to BRAC. Many of these initiatives have a shorter project timeline, thus creating a greater sense of urgency and visibility.

It is important to remember that change management extends beyond the initial transfer of missions and resources to DLA. Leaders at DLA and the Services must take an active sponsorship role and serve as strong advocates throughout their organization, driving all of the changes required by BRAC law while maintaining the best interests of DoD.

A final challenge to BRAC change management efforts includes measuring success. While it is possible to measure the number of hits at a frequently asked questions Website, talking points developed and delivered to leadership, articles published, and brochures handed out at town halls, it could be argued that this does not reflect effectiveness. Ideally, if the goals of BRAC change management at DLA are to help ensure the successful transition of employees to DLA, prepare the workforce for the culture shift necessary to take on new mission, and help instill confidence in its customers, DLA metrics should measure these activities. Once appropriate metrics are defined, distilling change management efforts from other internal and external factors will be a challenge. Research has clearly shown that effective change management works, and so DLA officials will continue their attempts to define effectiveness, measure progress, and course correct as necessary.

For more information on the BRAC 2005 Supply and Storage decisions, please visit https://today.dla.mil/BRAC/default.asp.

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Retrograde Transit Normalization Study (RETRNS)—A Preliminary Investigation into Variance in Retrograde Processing

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Introduction

The speed with which carcass-constrained retrograde assets flow through the retrograde cycle (from base supply to the depot) matters. It matters because the Air Force's procurement and planning processes use the depot repair cycle time (DRCT) as a variable in worldwide buy and repair requirements. Our primary interest lies within a component of this large pipeline called reparable intransit (RIT).[1]

In 2006, Air Force Materiel Command, Supply and Engineering Requirements Division (AFMC/A4Y) ran a simulation using the Aircraft Availability Model (Logistics Management Institute) and the September 2005 D200A annual year (AY) data set to test the consequences of reducing reparable intransit time by 10 to 30 percent. At a 30 percent reduction in processing time, buy requirements would decline by \$12.5M and repair requirements would decrease by \$4.8M for a total savings of \$17.3M.[2]

In February 2007, AFMC/A4YR ran this simulation on the September 2006 D200A annual year (AY). The simulation showed that a 30 percent reduction in retrograde cycle time would result in a reduced buy requirement of approximately \$32M and a reduced repair requirement of about \$11M. These estimates must be tempered by the fact that in an actual production run additional D200A business rules would come into play as well as a post-D200A process that completes the budget estimate.[3]

Whether faster shipping times would lead to cost savings has recently been called into question.[4] The essence of the argument is that while carcass-constrained assets should be expedited, other assets should be moved more slowly to save on transportation costs. Supporting this perspective is the fact that the Air Force employs a repair on demand (ROD) system for reparables—assets not in demand end up being stored at a depot until a specific repair request is made. In short, the point is made that it makes little sense to ship assets express (given the attendant costs) just to have them sit on a shelf waiting to be needed. The authors used a Monte Carlo simulation to demonstrate that at the 99.99 percent confidence level adding a couple days to shipping time does not increase back orders .

In the 2006 AFMC/A4YR simulation cited previously, 7,138 assets were implicated in the projected savings. At the time the simulation was performed, all of these assets were carcass constrained by definition because they were in a buy position.[5]

While it is true that D200A does not include depot storage time as a variable in DRCT, this fact does not invalidate the projected savings due to increased retrograde pipeline velocity. In effect, DRCT encapsulates storage time, but since the DRCT pipeline clock stops after the receipt of the asset at the depot and does not start again until a repair order is placed—storage time has no impact on its calculations. Hence, storage time is not relevant for the calculations. Another way of looking at it is that there is storage time associated with an asset only if the asset is not carcass constrained. Therefore, whether the ensconced model always reflects the reality of asset movement and repair demands is beside the point, because it is only changes in *model* parameters that affect buy and repair requirements. Whether a more suitable and responsive model can be developed is beyond the scope of this study but has been recently addressed by the RAND Corporation.[6] Perceived limitations in the current D200A model are discussed in that report.

Furthermore, since there appear to be two definitions of carcass constraint—the one used by D200A and the daily fluctuations tracked by EXPRESS[7]—even if some of the assets viewed as carcass constrained in the D200A simulation were not viewed as carcass constrained by EXPRESS, an alternative to slower shipping times is to decrease inventory levels (and hence buys), thus reducing the *slack* in the system. Masciulli et al.[8] discuss the tradeoff between transportation speed and inventory investment. Using the Aircraft Availability Model, they estimate that a 6-day increase in order and shipping time (O&ST)[9] time due to slower transportation will increase the spares requirement to the tune of $96M while that cost can be avoided by paying an additional $17M for faster transportation.

A later study by Masciulli,[10] found that saving $493K in transportation costs would result in a $7.68M increase in additional inventory. Furthermore, the author calculated that it would take the Air Force 15.67 years for the transportation savings to pay for the additional inventory.

Given the preceding, we posit that increasing retrograde pipeline celerity is indeed a generalized good to be sought by the Air Force. The Wall et al. model and the D200A simulations are not necessarily contradictory. However, if in practice pipeline celerity is increased and inventory levels decreased as a result, then when the repair on demand (ROD) model kicks in after the changes in inventory have taken place, increasing transportation time 2 days might well have a deleterious effect on expected back orders. Thus the purportedly benign feature of increasing transportation time would evaporate under a less slack asset distribution system. Modeling the above, however, is beyond the scope of this study. We turn now to an exploration of the factors that might explain the variance in reparable intransit pipeline times.

Analysis of Retrograde Pipeline Data

The simulations run by AFMC/A4YR show that the Air Force would reap savings by increasing the retrograde pipeline speed. The question is whether reducing pipeline time is a practicable and achievable goal. The short answer is yes, if similarly situated bases perform differentially. Since they do, increasing overall pipeline speed is largely contingent upon reducing the mean pipeline time for poor performers. We can broach this issue first by looking at the current performance vis-à-vis Air Force standards and second, by comparing performance among bases.

The Air Force cargo movement regulation stipulates standards ranging from 2 to 5 days depending upon origination and destination points. The pipeline referenced in these regulations runs from base supply to carrier delivery at a source of repair and

Article Acronyms

2LM – 2-Level Maintenance
AFB – Air Force Base
AFMC – Air Force Materiel Command
AMC – Air Mobility Command
ANG – Air National Guard
AOR – Area of Responsibility
AY – Annual Year
CMOS – Cargo Movement Operations System
CONUS – Continental United Sates
D6 – A receipt
D7 – Issue
D7x – This is a type of shipping document.
DDC – DLA Distribution Center
DIFM – Due-In From Maintenance
DoDAAC – Department of Defense Activity Address Code
DLA – Defense Logistics Agency
DRCT – Depot Repair Cycle Time
eLog21 – Expeditionary Logistics for the 21st Century
FSC – Flight Service Center
FY – Fiscal Year
GATES – Global Air Transportation Execution System
IREP – Intermediate Repair and Enhancement Program
IWSS – Integrated Weapon System Support System
MAJCOM – Major Command
MICAP – Mission Capable
NMCB - Not Mission Capable Both
NMCM – Not Mission Capable Maintenance
NMCP – Not Mission Capable because of Policy
NMCS - Not Mission Capable Supply
O&ST – Order and Shipping Time
OCONUS – Outside the Continental United States
REA – Retrograde Exception Analysis
REMIS – Reliability and Maintainability Information System
RETRNS – Retrograde Transit Normalization Study
RIMCS – Reparable Items Movement Control System
RIT – Reparable In-Transit
ROD – Repair on Demand
ROD – Report of Discrepancy
SBSS – Standard Base Supply System
SF – Standard Form
SHP – Shipping document
TMO – Transportation Management Office
TP – Transportation Priority

thus differs from RIT in that it does not include the time it takes to issue a receipt at a depot.[11] The Air Force cargo movement time standards are also based on agile logistics requirements which pertain only to air eligible transportation priority (TP) 1 and 2 assets.[12]

Defense Logistics Agency (DLA) distribution centers (DDCs) have a standard of 3 days from carrier delivery to the issuance of the receipt.[13] In combination, these standards equate with the RIT pipeline. Therefore, the maximum allowable time for TP1 and TP2 retrograde to move from base supply to the issuance of a receipt at a depot is 8 days. How does the Air Force current system fare? Table 1 shows the expected value versus the mean for the group, as well as the percent that meets the standard.

From an auditing standpoint, there are serious issues of noncompliance with promulgated retrograde shipment standards, with the Germany-United Kingdom to the continental United States (CONUS) group the most out of tolerance. However, our purpose here is performance improvement and while standards provide a reference point for current performance vis-à-vis expectations, they are not sufficient to determine what can be done in practice.

One approach is to compare the performance of similarly situated bases (mission, geography). An example based upon geographical location comparing non-reserve Air Force bases highlights the vast performance differentials. Table 2 compares two sets of bases in close geographical proximity, yet with highly divergent RIT days to 3 DDCs (Hill Air Force Base [AFB], Tinker AFB, and Warner Robins AFB). Note the consistent performance difference in each pairing irrespective of the ship-to address.

While this limited selection of base pairs proves nothing conclusively, it demonstrates in these cases that RIT is not simply correlated with geographical distance from an air logistics center. Given delivery guarantees from commercial carriers, this is not a surprise. The consistent performance differentials of the compared bases could, however, be indicative of operational factors in action.

Retrograde Shipment from:	Base Processing and Transit Time Standard (days)	Mean (days)	N	Std Dev (days)	Percent Compliant
CONUS TO CONUS	2	3.45	52,672	4.2	50.5
Germany/UK to CONUS	3	5.73	2,194	4.3	29.9
Italy/Japan to CONUS	4	6.64	1,334	6.9	60.0
Korea/Southwest Asia and others to CONUS	5	5.06	4,744	4.1	72.3
Total		3.73	60,944	4.3	

Table 1. Retrograde Shipments versus Air Force Cargo Movement Standard by Group

	Distance To ALC1	RIT	Distance to ALC2	RIT	Distance to ALC3	RIT
Base 1a	2,130	17.6	950	14.6	319	11.8
Base 1b	2,237	4.4	1,156	5.2	320	4.7
Base 2a	846	10.2	1,018	11.9	1,971	9.5
Base 2b	961	5.0	1,044	4.0	1,842	6.3

Table 2. Comparison of Geographically Similar Bases

Aside from these base-to-base comparisons, what does the performance picture look like across all Air Force bases? Using a data set from the TRACKER database obtained from AFMC/LSO in 2006, the median RIT for an unserviceable asset moving back to a source of repair was 7 days with the modal occurrence being 6 days (see Table 3). Aggregation by base shows RIT averages ranging from slightly under 4 days to 33 days.

In March 2007, we obtained a second TRACKER dataset from AFMC/LSO covering fiscal year (FY) 2006. The mean time from the issuance of the D7x (shipping document)[14] to the acknowledged receipt at the depot was 9.47 days.

Decomposition into Pipeline Segments

Juxtaposing current retrograde performance to standards and comparing performance across bases helps illustrate the current state of processing unserviceable but reparable assets. But before we can address how to improve retrograde movement performance, it is necessary to disaggregate RIT into its constituent pipeline segments. From an enterprise view, the retrograde chain is comprised of three sequential functional arenas: base supply and transportation management office (TMO) processing, carrier possession, and the depot distribution centers.[15] Splitting RIT into its three functional components produces the following pipeline times:[16]

- Turn-in to carrier pickup takes an average 1.91 days
- Carrier possession time is 1.88 days
- Depot induction takes 3.32 days

The 2007 data was comparable.

Of the approximately 212,000 shipping documents obtained from the 2006 TRACKER dataset, 68,197 records had all of the constituent components of RIT. It is this subset which is used in the following analysis.

As previously indicated, average processing times vary considerably from base to base. Just looking at bases with 100 or more shipments during the period under consideration, the base supply to the TMO pickup segment ranges from less than 1 day to over 21 days. The period covering carrier delivery to the D6x (materiel receipt) at the depot ranges from 1.92 days to 6.3 days. While the former segment is due to base processes the latter is likely the result of both base and depot operational processes.

A visit to the DLA at Tinker AFB in 2005[17] indicated that the lag from carrier delivery to the issuance of a D6x was largely the result of discrepancies discovered during the receipting process (D6). A primary complaint was that the packages arrived from the base without proper documentation needed for identification. If these problems are representative

across the DDCs, then the delay in issuing a D6 could be attributable partially to practices in base processing.

Additionally, data quality issues on the base end of RIT have been identified by retrograde exception analysis (REA) audits.[18] Specifically identified were incorrect ship-to addresses, improper labeling, and an issue of timeliness with respect to DLA receiving the prepositioned materiel receipt documents before receipt of an asset.

The differential performance of base operational processes can only serve as part of the explanation for the variance seen in the pipeline segment covering depot receiving and issuance of the D6 receipt. When that period of time is disaggregated by the depot, there are statistically significant differences among the depots. The average time to process the D6 after delivery of the item was 2.11 days at Tinker, 3.57 days at Hill, and 4.42 days at Warner Robins (see Table 4). Using the 2007 data, receipts took almost 10 days to process at the Cryptologic Depot at Kelly AFB while the receipting process at Boeing for C-17 repairs took slightly more than 1 day on average. The 2007 data indicates that Warner Robins improved their performance to approximately 3.25 days. Hill and Tinker performances were comparable to what they did in 2006.

While Tinker has the best mean time to D6 receipt, it also had a larger variance in processing this receipt. This indicates that while it performs the best overall, it also has a larger number of shipments that are outliers. It is worth noting that Tinker is the only organic operation of the three. What explains these differences in processing time is as yet unknown. However, these differences in mean processing time show that depot processing practices cannot be ignored as a variable explaining the delay in issuing the D6.

To further explore the base and depot process variances we used regression analysis[19] to build a series of models to test various hypotheses. First, we explored what we call the Expected Regulatory Framework model. If the regulatory framework that guides retrograde processing fully governed the operational characteristics and permeated behavioral practices of base supply and TMO processing, then we would expect certain results to follow and we would expect that any variance could be largely explained by key regulatory variables. For example, assets shipped under TP1 should arrive more quickly on average than TP2 and TP2 before TP3. What we find is that TP1 has a mean of 8.8 days for RIT, while TP2 actually arrives faster at 8.4 days. True to expectations, TP3 comes in with the slowest transportation time with an average of 9.8 days.

If we plug transportation priority, MAJCOM (as a proxy for mission), number of shipments (to control for the fact that the shipping volume varies considerably among the bases and may create efficiency effects), weight and quantity of assets shipped, into a regression equation seeking to explain the variance in the base supply to the carrier pickup at the TMO, these variables account for only 6.3 percent of the variance (R^2).

A second regression model replaced MAJCOM with variables specific to the weapon system type and number found on each base.[20] This was viewed as a more precise representation of mission as well as the regulatory and contractual realities related to specific weapon systems. This model allows us to explain 11.6 percent of the variance.

Our third model adds a dummy variable for each base. These variables serve as proxies for the operational characteristics that define each base's retrograde activities. The explanatory power of this model is 37.2 percent. Hence, without being able to know what characteristics about base supply and TMO processing matter, we can assert that they exist and bear further investigation.

N		Valid Missing	136,856 76,170
Mean		8.69
Median		7.00
Mode		6
Std Deviation		8.633
Minimum		0
Maximum		371

Table 3. Reparable Intransit Descriptive Statistics

DDC	Mean	N	Std Deviation
Hill	3.57	24,448	3.292
Tinker	2.07	23,067	5.008
Warner Robins	4.41	20,682	3.722
Total	3.32	68,197	4.181

Table 4. Carrier Delivery to D6 Receipt

Turning now to that pipeline segment that runs from carrier delivery at the depot to issuance of the D6x (receipt), we find that a model that includes the depots as proxies for operational practices, bases, weight and quantity, and transportation priority explains 7 percent of the variance. The variables with the largest explanatory power are the dummy variables representing the three DDCs indicating that even controlling for the aforementioned variables, depot processes have the largest impact on receipt processing time. Furthermore, with Hill serving as the baseline, Tinker's beta coefficient for the regression equation indicates that a shipment to that depot was processed 1.4 days more quickly than average while a shipment to Warner Robins took 0.9 days longer.

Thus we reach the crux of the reason for the study. While the foregoing data analysis identified a wide performance range, we were not able to explain a satisfactory amount of the variance in our two pipeline segments of interest. The stark performance differentials among bases strongly hint that obtaining greater understanding of this performance variance can best be gleaned from analyzing the processes and systems that are reflected in the pipeline segments. The primary goal of this study is to begin to elucidate the factors that explain the variance in base supply and TMO processing. We will also investigate to a much more limited degree the carrier delivery to issuance of the D6x segment to probe whether DDC processing of the D6x is primarily affected by depot- or base-level processes. We will not investigate carrier possession time.

RETRNS Research Design and Analytic Framework

We are interested in learning what factors or characteristics account for the efficient and effective functioning of base supply and TMO operations. By efficient we mean faster movement from turn-in until a shipment is made ready for carrier pickup. By effectiveness, we recognize that speed should not create a situation where the state of the package received by the depot

(or an intermediate facility like a port) creates delays because of incomplete or missing documentation. Therefore, base operational practices impact both the immediate pipeline segment that captures their performance as well as that segment which putatively reflects depot performance.

In order to obtain a fuller understanding, we selected six bases and one depot to study retrograde shipment and reception processes.[21] Sites selected include outside the continental United States (OCONUS) and CONUS bases. Since we are studying the reverse logistics and supply chain of bases both outside and within the United States, it is essential to understand and make transparent the nature of the challenges each faces.

The case study should allow for the emergence of differences in procedures, data input practice, personnel staffing and training factors, technology, as well as incentive structures that function to create priorities for those working within the processes.

This study comports with the Expeditionary Logistics for the 21st Century (eLog21) initiative which places process reengineering at the core of that transformation.[22] Being able to articulate best retrograde practices will set the stage for future process reengineering.

RETRNS Study Methodology

Our intention for the case study was to document retrograde practices as-is. We were not there as auditors asserting how something ought to be. Instead, we were interested in capturing how work was actually performed and then to take insights from those observations and relate them back to the data, as well as conceptualize possible next steps.

There were four members of our team. Each visit utilized the same qualitative method whereby we started with a number of conceptual categories that we hypothesized might be relevant for performance differences. Each member took notes with those categories in mind, as well as actively listening to our hosts articulate their processes and what they experienced from their perspective. One team member created a number of process maps to capture the flow of both retrograde and personnel. As there were similarities in these flows, we did not map each site.

After each visit, observations and conversations were triangulated to produce a consensus about what we saw and heard, and what appeared to be the primary factors of interest. When there were different interpretations among team members clarification was sought via phone calls and e-mails with our hosts.

The research method used by the team was both exploratory and organic as the insights that emerged from each site visit were then incorporated into the knowledge frame we took to the next visit. In essence, the team practiced a form of abductive reasoning whereby the collective *facts* of the retrograde operations we viewed were then used to create hypotheses about the relevant evidence.[23]

Findings and Process Constructs of Interest

Any actual process is contingent upon certain determining inputs. A number are pertinent here: local practice, policies and regulations, local incentives and leadership, training and staffing levels, physical layout and work environment, and data systems and technology. We discuss pertinent findings within each below.

Base Supply and TMO Processing

- The current retrograde processes in themselves varied from base to base. The majority of operations had the following asset flow: Maintenance turn-in to supply (either picked up by supply, or delivered by maintenance, or both), item checked against documentation, shipping document cut (TRIC SHP), asset transferred to TMO, then in-checked, packaged, and carrier selected.
- Certain bases had multiple process flows as a result of shipments into the area of responsibility (AOR) as well as base originating retrograde. At one base the second retrograde flow had no interface with the flight service center (FSC), except to exchange improperly addressed packages. This second flow was contractor-run with one contractor serving as both a source of supply and repair. This contractor also utilized subcontractors for repair depending upon the weapon system.[24]
- AOR shipments were generally viewed as the most error-laden. AOR shipments were often missing documentation or contained incomplete or erroneous documentation that required the receiving bases to research to correct the uncertainties. Another time-consuming delay was when midstream receiving destinations (such as ports) had to repack an asset before forwarding to the DDC.
- There was no standard procedure for how retrograde moved from the maintenance backshops to supply. Some bases had supply make regularly scheduled runs to pick up parts. Others had maintenance deliver parts to supply. Still others allowed both. Maintenance-to-supply deliveries of retrograde were considered at one base to interfere with maintenance activities because maintainers had to stop what they were doing and deliver parts to supply.
- We obtained a report of discrepancy report (ROD) from DLA for the last 9 months of FY06. Table 5 shows the discrepancies as indicated by the three Air Force depots. Curiously, slightly less than 97 percent of these discrepancies

Discrepancy Category	Discrepancy Type	Discrepancy Count	Percent of Total
C	Condition other than indicated	170	3%
D	Documentation missing/incomplete	487	9%
M	Misdirected assets	69	1%
O	Overage	9	<1%
P	Packaging	3455	65%
S	Shortage	36	1%
T	Technical Data Missing/Incomplete	279	5%
W	Wrong Item	742	14%
Z	Other	35	<1%
		5282	100.00%

Table 5. Discrepancy by Category

were reported by Warner Robins. Do personnel at the Warner Robins DDC notate discrepancies with greater regularity? Tinker's lack of discrepancy data conflicts with the anecdotal comments previously received from personnel at that DDC about the many problems with incoming assets.

- Packaging was the largest problem representing approximately 70 percent of the discrepancies for that period. Other notable problems included the depot receiving the wrong items indicated on the supply documentation (14 percent) and missing or incomplete supply documentation (9 percent).[25] Table 5 contains a breakdown by discrepancy category.
- These discrepancies cause delays at the depot by frustrating the issuance of the receipt acknowledgment (D6). This won't matter much for reparables that have no demand, but for those that do, the impact is to directly reduce aircraft availability. Table 6 shows the net effect for the four primary discrepancy categories using Warner Robins data only. With no other factors considered, a retrograde shipment will take 7.1 days from carrier pickup to issuance of the D6 receipt at the depot (herewith named TransDays). Missing or incomplete documentation adds about 3.5 days to processing. Packing issues and wrong items add approximately 1.5 days. When technical data (inspection or serviceability information) is missing or incomplete, the discrepancy adds almost 9 days to processing. While the number of discrepancies is small relative to total retrograde shipments, when they exist they cause statistically significant delays in processing at the depot.
- Besides causing delays in retrograde processing at the receiving facilities, discrepancies create additional processing costs because they necessitate an SF-364 (report of discrepancy) being filled out as well as followup actions on both ends of the transaction. In general, discrepancies are indicative of the effectiveness of base operations and as such provide an additional perspective to complement base supply and TMO efficiency metrics pertaining to retrograde processing. For bases with at least 120 shipments during the period studied, the percent discrepant ranged from a low of 2.7 percent to approximately 31 percent.
- Improper packaging appeared to be propagated throughout the system as bases sometimes received serviceable assets from the depot in improper packaging.
- AMC had only one flight out of Aviano a week.
- Non-express items can sit on the truck at the loading dock for up to 72 hours over the weekend waiting for a full truck load.
- Customs officials will sometimes pull assets even after a truck has been ordered, thus delaying departure.

Policies and Regulations

Policies, regulations, and contract specifications create defining process features. These features or artifacts create the rules framework within which individuals function. Process improvement then would entail more than efficiency adjustments. It would require review of policy obligations as to their importance in light of the goals of the process and a determination whether the rules impede or accelerate movement toward the goals. Sometimes there is no leverage with respect to policy obligations—they must be observed. Other rules and practices are nothing more than bureaucratic residue without present validity. Opportunities exist in this conceptual space.

Certain inefficiencies resulted due to operational structures arising from contracts. One subcontractor stated that they regularly received improperly documented retrograde from the AOR. Researching the asset required not only researching databases such as Reliability and Maintainability Information System (REMIS) but also contacting the FSC. This subcontractor used to have direct access to the FSC but now under their new Integrated Weapon System Support System (IWSS) contract they had to funnel requests through the prime contractor. This created delays in processing the retrograde.

Discrepancies	Processing Days Added
(Constant)	7.1
Documentation	3.6
Packing	1.6
Technical Data	8.9
Wrong Item	1.7

Table 6. Primary Retrograde Discrepancies and Impact on Processing of the D6

The standard reasons tracked for why an aircraft is not mission capable are:

- Not Mission Capable Maintenance (NMCM)
- Not Mission Capable Supply (NMCS)
- Not Mission Capable Both (NMCB)

There apparently exist instances where there is another cause of an aircraft being not mission capable. It appears that depots operating under the Repair on Demand system will wait until they reach a quota with respect to certain parts requests. One base we visited had a recurring problem with a depot, because unserviceable items were held until a quota was reached before spare parts were ordered, thus prolonging the *hole in the plane*. This appears to be an example of *NMCP*, (not mission capable because of policy). While this particular policy feature will not impact retrograde cycle time, it may have a significant impact on aircraft availability and MICAP hours.

Local Incentives and Retrograde Leadership

The importance of organizational culture was made apparent on our first visit and resonated throughout the project. The high priority of retrograde processing was evidenced at that base by *constant communication*, weekly due-in from maintenance (DIFM) monitors meetings, a How Goes It Supply Meeting, a monthly IREP (Intermediate Repair and Enhancement Program)[26] meeting that brought supply and maintenance personnel together to discuss 2LM timeliness and processing time metrics, and periodic meetings to allow supply and maintenance personnel to understand each other's needs. This latter meeting provided a forum for interfacing areas of responsibility to discuss issues of relevance to both. There was also some cross training exercises. Furthermore, TMO procedures for in-checking into the cargo movement operations system (CMOS) were posted on the wall above the computer stations. This made knowledge available for quick reference (efficiency) to all (lessens the learning curve).

Such leadership and prioritization of retrograde movement was glaring in its absence at some other bases. In general, the observed organizational culture correlated with the objective performance of retrograde processing both in terms of efficiency and effectiveness (fewer discrepancies at the depot).

Training and Staffing Levels

When asked about what made their operation function well, one response was that a high volume of retrograde had forced them to get it right. Practice makes perfect. At another base, they stated that high volume overcame their ability to process retrograde smoothly. This apparent contradiction was then tested with the data. Shipping volume was correlated with base supply and TMO processing time for each MAJCOM. With the exception of AFMC and ANG, the other MAJCOMs saw an increase in pipeline speed as shipping volume increased. Air Education and Training Command's (AETC) correlation was not significant. This result may call into question the importance of minimum staffing levels. Table 7 shows the correlation of MAJCOM with base supply and TMO processing time as well as the corresponding significance level and the number of shipments.

Deployments were often considered to be problematic. The civilian force was generally viewed as a stabilizing force given the deployments. However, since the knowledge and experience level of the civilian personnel varied, the tradeoff was not always equivalent. Some of the civilian personnel were temporary federal employees. With lower pay and uncertain futures, more experienced and capable individuals would not be attracted to such a position. Given the incentives such a classification creates, the military personnel often had greater command of the work that needed to be performed. Hence deployments could, depending upon the replacements available, create process inefficiencies.

ANG	
Pearson Correlation	.070(**)
Sig (2-tailed)	0.000
Shipments	16,991
AFRC	
Pearson Correlation	-.136(**)
Sig (2-tailed)	0.000
Shipments	2,206
ACC	
Pearson Correlation	-.120(**)
Sig (2-tailed)	0.000
Shipments	16,176
AETC	
Pearson Correlation	d
Sig (2-tailed)	0.073
Shipments	11,877
AFMC	
Pearson Correlation	.148(**)
Sig (2-tailed)	0.000
Shipments	5,504
AFSPC	
Pearson Correlation	-.331(**)
Sig (2-tailed)	0.000
Shipments	509
AMC	
Pearson Correlation	-.125(**)
Sig (2-tailed)	0.000
Shipments	6,156
USAFE	
Pearson Correlation	-.287(**)
Sig (2-tailed)	0.000
Shipments	3,076
PACAF	
Pearson Correlation	-.129 (**)
Sig (2-tailed)	0.000
Shipments	4,884
** Correlation is significant at the 0.01 level (2-tailed).	

Table 7. Correlation of Base and TMO Processing Time with Shipments (by Selected MAJCOM)

Physical Layout and Environment

Flight service centers collocated with TMOs created process efficiencies as well as a collaborative work environment. The relative importance of collocation is not known.

Clean and organized workspaces were the norm with one exception. This exception also had the worst processing time among the bases we visited.

Data Systems and Technology

The use of SATS (Supply Asset and Tracking System) varied by base. Use ranged from not at all to being employed by base supply only to use by both supply as well as maintenance back shops. Funding limitations appear to be one reason why certain bases did not have the technology.

One consistent complaint was that RIMCS (Reparable Item Movement Control System) data was not being updated frequently enough. Another problem with RIMCS was that Department of Defense activity address codes (DoDAAC) apparently were being overwritten by shippers resulting in misrouted shipments. Why this occurred is not known.

We received complaints about GATES (Global Air Transportation Execution System) interfacing with CMOS and data system disconnects between SBSS and CMOS.

Conclusions and Recommendations

RETRNS was born in the realization that there was a vast gulf in performance among bases in the processing of retrograde. Various analyses seeking to explain the variance in performance found significant factors but most of these were proxy variables that crudely represented base and depot processes. The goal of this study was to begin to peer beneath the data and to attempt to ascertain through observation and conversation what factors may truly provide an explanation for the differential performance that the data conclusively showed existed. Over the course of the study we obtained valuable insights about the why. In effect, we now have a much clearer understanding about the likely factors that appear to matter most for pipeline celerity.

Given the multidimensionality and multi-organizational nature of the retrograde system, it stands to reason that what needs to be done to improve the current system would not be monochromatic. Primary constructs of interest that warrant further investigation include: the importance of organizational culture, data system interface limitations and the need for further data integration, variable quality control on retrograde shipments especially from the AOR, the perceived negative effect of deployments on operational functioning, and the impact of staffing levels on processing efficiency and effectiveness. These factors appear to be important contributors to: efficient and effective base supply and TMO operations, the operational efficiency and manpower costs of intermediate bases such as ports, and the processing of retrograde at the depot.

The following recommendations are those that would appear to provide the greatest impact on retrograde as a system.

- Discrepancies in retrograde shipments received at the depots inhibit processing at the depot. If these discrepancies are holding up carcass-constrained items, then these delays are directly impacting aircraft availability. Another impact is

more widespread. Since all discrepancies require the filing of an SF364, resources are being wasted in resolving them. Further training may resolve these problems. We suggest widespread dissemination of a set of efficiency and effectiveness metrics: base supply and TMO processing time, DDC processing of the D6 after carrier delivery of the asset, and a discrepancy ratio (total shipments – perfect shipments/total shipments) or alternatively a perfect shipment ratio (total shipments-total discrepancies/total shipments).

- Projected savings from increasing retrograde pipeline speed range from $17.3M to $43M. Retrograde processing needs to be reduced approximately 3 days to effectuate these savings. Two years of data have shown that it takes approximately 3 days from the delivery of the asset at the depot to its being receipted. Two-thirds of these projected savings could be realized if that process can be reduced to 1 day.
- As business rules are written for the Expeditionary Combat Support System, the existing interoperability problems between GATES and CMOS as well as between SBSS and CMOS should be addressed.
- All bases that we visited that served as intermediate or final shipment points for retrograde expressed displeasure with AOR shipments. How can these processes be improved given the exigencies that AOR bases face? A process improvement study to explore this in more detail is warranted.
- Organizational culture undoubtedly contributes to the processing variations that the data exhibits. A census of base supply and TMO operations may contribute to our understanding of best practices.
- Deployments of experienced personnel were viewed as a problem. How can base supply and TMO operations best maintain their operational capabilities given these demands? Investigating how the need to train military personnel in their chosen fields can be balanced with the need for operational efficiency deserves further attention.
- There are two distinct enterprise issues with retrograde movement in the Air Force. The first involves assets that are not carcass constrained. Because of the ROD system, carcasses sit at the depot until a demand is made. It is this fact that leads some to suggest the slower movement of reparables. Instead, we view this as an inventory control problem best addressed by reducing inventory levels.
- The second enterprise level issue pertains to carcass-constrained assets. How to improve the attendant policies and processes such that MICAP hours are reduced and aircraft availability enhanced becomes the crucial question. It is the subset of all retrograde that have MICAP hours accruing while they are also carcass-constrained that should arguably receive the future focus in studying the impact of retrograde asset movement. Such carcass constrained assets are delayed by at least two causes. The first is the speed with which needed carcasses move through the relevant processes and pipeline segments. Second, are those instances when a repairer is put on hold because the depot is waiting to meet its quota before parts will be ordered or repairs performed. This is effectively a policy limitation which we call NMCP, or not mission capable because of policy.

Whatever specific courses of action are chosen, it is imperative for the Air Force to continue to study how the flow of reparable, unserviceable assets can be improved. Improvements to the various interfacing operations and systems by any of the aforementioned means may work towards the enhancement of aircraft availability and provide cost savings irrespective of whether that is through inventory reduction or increased pipeline velocity and its attendant reductions in buy and repair requirements.

Notes

1. Retrograde Cycle Time is comprised of three supply chain segments: base and transportation management processing, carrier possession time, and depot possession time that encompasses receipt from carrier to issuance of the D6 transaction.
2. Bob McCormick, "Requirements Analysis – Reparable Intransit Pipeline Changes," 21 April 2006.
3. Bob McCormick, "Requirements Analysis – Reparable Intransit Pipeline Changes," 20 February 2007.
4. Captain David Wall and Major Edward Snow, "Analysis of the Repair Cycle," AFLMA Final Report LS200511600, Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, June 2006.
5. *Logistics System Training Program, Secondary Items for D200A, Student Study Guide*, May 2003. Also see AFMCMAN 23-1, "Requirements for Secondary Items," [Online] Available: http://www.e-publishing.af.mil/shared/media/epubs/AFMCMAN23-1.pdf. The buy position is defined as the smaller of the third short position (after applying depot repairs) at the buy period or the termination period.
6. Richard Hillestad, Robert Kerchner, Louis W. Miller, Adam Resnick, and Hyman L. Shulman, *The Closed-Loop Planning System for Weapon System Readiness*, RAND Corporation, [Online] Available: http://rand.org/pubs/monographs/2006/RAND_MG434.pdf, 2006.
7. See AFMC Instruction 23-120, 2.4.1.1 for definition of carcass availability used by Express.
8. Captain Jason L. Masciulli, Captain Christopher A. Boone, and Major David L. Lyle, "Premium Transportation: An Analysis of the Air Force Usage," *Air Force Journal of Logistics*, XXVI, No 2, 2-7.
9. AFMCMAN 23-1, Chapter 9.4.1.1. Base OS&T days are the time that elapses between request for a serviceable item and receipt.
10. Captain Jason L. Masciulli, "Looking at the Best Way to Get There: Comparing the Cost Effectiveness of Two Means in Moving Aircraft Spares," *Air Force Journal of Logistics*, XXIX, No 3/4, .35.
11. AFI 24-201, Attachment 2, "Table of Air Force Pipeline Time Standards," 10 March 2005. Confusingly, the Air Force has another set of retrograde movement standards (UMMIPS) AFMAN 23-110, Vol. 1, Part 1, Chapter 23, Attachment 24D-1, "USAF Retrograde Material Movement Pipeline Guidelines." Under these guidelines virtually all retrograde shipments in this dataset were compliant as the standards range from 8 days in CONUS for TP1 to 30 days for TP3. Area 4 (hard lift areas) standards range from 21 days to 93 days. Areas 1-3 range from 16 to 83 days.
12. AFI 24-201, *Agile Logistics and Contingency Operations*, 10 March 2005.
13. See DLA Distribution Center Website. [Online] Available: http://www.ddc.dla.mil/.
14. There are various D7 and D6 transactions. The use of just D7 or D6 is meant to be inclusive.
15. In terms of transactions, RIT encompasses the following supply chain segments: it starts when a ship document (D7) is issued by base supply; continues at the transportation management office after pickup or delivery; in-checked where a YRO is generated; packaged; carrier selection made; picked up by the commercial carrier at the base (YLN generated); delivered to the depot by the carrier; and ends when the depot issues a D6 receipt.
16. Data is from the TRACKER database. N=68,197, May 2005 – May 2006. A data subset was created that covers shipments to the Warner Robins, Hill, and Tinker depots only.
17. Visit in December 2005 involved personnel from AFMC, DLA, and the OK DDC.
18. These audits are performed by AFMC/A4W.
19. These predictive models take the following linear regression form: $Y=a=bx_1+bx_2+...bx_n=e$.
20. Variables were created such that for every weapon system each base was assigned a number which represented the percentage that each weapon system's comprised of the base's total contingent of aircraft. The default was 1 (no aircraft of that type), so that a base that had

F-15s that comprised 75 percent of their total aircraft was assigned 1.75 for the F-15 variable.

21. The following criteria were used to select bases to visit:
    a. MAJCOM has REA representative. This eliminates AETC and AFRC.
    b. One OCONUS base shipping to US port
    c. One CONUS base (port) receiving from OCONUS
    d. Two other, US continental bases from regular Air Force.
    e. Two bases from ANG.
    f. A mix of bases in particular those who have consistently better or worse performance in shipments to all ALCs.
    g. Minimum 1000 shipments per year for regular Air Force. Minimum 400 shipments per year for ANG.
22. See eLOG21 Overview.pdf, Air Force Portal Website, 4 August 2004, 5.
23. Uwe Wirth, *What is Abductive Inference*, [Online] Available: http://user.uni-frankfurt.de/~wirth/inferenc.htm
24. Various process flow maps were constructed and are available.
25. Data received from DLA on 15 February 2007. See DLAI 4140.55 for the regulation concerning the reporting of supply discrepancies and attendant discrepancy codes, [Online] Available: http://www.dla.mil/dlaps/dlai/i4140.55.htm#REPORTING_OF_SUPPLY. SF364 is used to report discrepancies.
26. AFI 21-101, *Aircraft and Equipment Maintenance Management*," [Online] Available: http://www.e-publishing.af.mil/shared/media/epubs/AFI21-101.pdf, 29 June 2006.

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Historical Perspective

The battle is fought and decided by the quartermasters before the shooting begins.

—Field Marshal Erwin Rommel

No matter their nationality or specific service, military logisticians throughout history have understood the absolute truth represented in the above quote. Whether they were charged with supplying food for soldiers, fodder for horses or the sinews of modern war—petroleum, oil, and lubricants (POL), they have understood that victory is impossible without them—even if, sometimes, it seemed their vital contributions were forgotten or ignored. None of the great military captains of history were ignorant of logistics. From Frederick the Great to Napoleon to Patton, they all understood the link between their operations and logistics. The great captains also have all understood that history had much to teach them about the nature of the military profession. Yet, military logisticians do not often spend time studying the history of military logistics.

There are at least three general lessons from history that might prove of some use in understanding how best to prepare for the future. The first of these is the best case operationally is often the worst case logistically. The second is promises to eliminate friction and uncertainty have never come to fruition. And the third is technological change must be accompanied by organizational and intellectual change to take full advantage of new capabilities. While these lessons are not exclusive to logistics, when applied to the understanding and practice of military logistics, they provide a framework for understanding the past and planning for the future.

Colonel Karen S. Wilhelm, USAF (Ret)

Concentration and Logistics

To win in battle we must concentrate combat power in time and space. Strategy and tactics are concerned with the questions of what time and what place; these are the ends, not the means. The means of victory is concentration and that process is our focus here. There are only four key factors to think about if we seek success in concentration. This is not a simple task. Although few in number, their impact, dynamics and interdependencies are hard to grasp. This is a problem as much of perspective as of substance. It concerns the way we think, as much as what we are looking at. The factors are not functions, objects or even processes. They are best regarded as conditions representing the nature of what we are dealing with in seeking concentration. They are as follows. Logistics is not independent. It exists only as one half of a partnership needed to achieve concentration. Why is understanding this so important? Logistics governs the tempo and power of operations. For us, and for our enemy. We have to think about the partnership of operations and logistics because it is a target. A target for us, and for our enemy. Like any target, we need to fully understand its importance, vulnerabilities and critical elements to make sure we know what to defend and what to attack. All military commanders, at all levels of command, rely on the success of this partnership. How well they understand it will make a big difference concerning how well it works for them and how well they work for it.

Wing Commander David J. Foster, RAF

Logistics and Warfare

General Mathew B. Ridgway, of World War II fame, once observed, "What throws you in combat is rarely the fact that your tactical scheme was wrong ... but that you failed to think through the hard cold facts of logistics." Logistics is the key element in warfare, more so in the 21st century than ever before. Success on the modern battlefield is dictated by how well the commander manages available logistical support. Victories by the United States in major wars (and several minor wars or conflicts) in the 20th century are linked more directly to the ability to mobilize and bring to bear economic and industrial power than any level of strategic or tactical design. The Gulf War and operations to liberate Iraq further illustrate this point. Long before the Allied offensive could start, professional logisticians had to gather and transport men and materiel and provide for the sustained flow of supplies and equipment that throughout history has made possible the conduct of war. Commanders and their staffs inventoried their stocks, essayed the kind and quantities of equipment and supplies required for operations in the severe desert climate, and coordinated their movement plans with national and international logistics networks. *"The first victory in the Persian Gulf War was getting the forces there and making certain they had what they required to fight* [Emphasis added]. Then and only then, would commanders initiate offensive operations."[1] The same may be said of lightning quick victory in Iraq, although without the massive stockpile of inventory seen during the Gulf War.

In 1904, Secretary of War Elihu Root warned, "Our trouble will never be in raising soldiers. Our trouble will always be the limit of possibility in transporting, clothing, arming, feeding, and caring for our soldiers...."[2] Unfortunately, the historical tendency of both the political and military leadership to neglect logistics activities in peacetime and expand and improve them hastily once conflict has broken out may not be so possible in the future as it has in the past. A declining industrial base, flat or declining defense budgets, force drawdowns, and base closures have all contributed to eliminating or restricting the infrastructure that made rapid expansion possible. Regardless, modern warfare demands huge quantities of fuel, ammunition, food, clothing, and equipment. All these commodities must be produced, purchased, transported, and distributed to military forces. And of course, the means to do this must be sustained.

Notes

1. Charles R. Shrader, *U.S. Military Logistics, 1607-1991, A Research Guide*, New York: Greenwood Press, 1992, 3.
2. Shrader, 9.

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The Themes of US Military Logistics

From a historical perspective, ten major themes stand out in modern US military logistics.

- The tendency to neglect logistics in peacetime and expand hastily to respond to military situations or conflict.
- The increasing importance of logistics in terms of strategy and tactics. Since the turn of the century, logistical considerations increasingly have dominated both the formulation and execution of strategy and tactics.
- The growth in both complexity and scale of logistics in the 20th century. Rapid advances in technology and the speed and lethality associated with modern warfare have increased both the complexity and scale of logistics support.
- The need for cooperative logistics to support allied or coalition warfare. Virtually every war involving US forces since World War I has involved providing or, in some cases, receiving logistics support from allies or coalition partners. In peacetime, there has been an increasing reliance on host-nation support and burden sharing.
- Increasing specialization in logistics. The demands of modern warfare have increased the level of specialization among support forces.
- The growing tooth-to-tail ratio and logistics footprint issues associated with modern warfare. Modern, complex, mechanized, and technologically sophisticated military forces, capable of operating in every conceivable worldwide environment, require that a significant portion, if not the majority of it, be dedicated to providing logistics support to a relatively small operational component. At odds with this is the need to reduce the logistics footprint in order to achieve the rapid project of military power.
- The increasing number of civilians needed to provide adequate logistics support to military forces. Two subthemes dominate this area: first, unlike the first half of the 20th century, less reliance on the use of uniformed military logistics personnel and, second, the increasing importance of civilians in senior management positions.
- The centralization of logistics planning functions and a parallel effort to increase efficiency by organizing along functional rather than commodity lines.
- The application of civilian business processes and just-in-time delivery principles, coupled with the elimination of large stocks of spares.
- Competitive sourcing and privatization initiatives that replace traditional military logistics support with support from the private business sector.

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